Attachment 1.

PRINCE WILLIAM SOUND AQUACULTURE CORPORATION

July 7, 2010

Ron Josephson
Section Chief
Fisheries Monitoring, Permitting, and Development
Alaska Department of Fish and Game
PO Box 25526
Juneau, Alaska 99802

Jeff Regnart, Regional Supervisor, Region II
Division of Commercial Fisheries
Alaska Department of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99518

James Hasbrouk, Regional Supervisor, Region II
Division of Sport Fish
Alaska Department of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99518

Dear Mr. Josephson, Mr. Regnart, and Mr. Hasbrouk,

This letter responds to the pink salmon portions of your April 19, 2010 letter addressing the Prince William Sound (PWS) Permit Alteration Requests (PARs) and complements my previous letter of May 31, 2010. PWSAC again appreciates the opportunity provided to review the Department's extensive document and present our comments and insight.

The April 19, 2010 letter addressed concerns regarding the PARs and used criteria of fisheries management, straying, genetics, and allocation in its evaluation. Our comments are outlined in a similar fashion. As stated in our earlier letter, the Department's document overlooks the historical permitted and production levels in PWS (see Attachment 1). Again, without that data, a reader could easily misinterpret the requested increases (as expressed in percentages) to be quite substantial without the ability to place them into proper context.

PRINCE WILLIAM SOUND AQUACULTURE CORPORATION
Corporate Office • P.O. Box 1110, Cordova, AK 99574
Office: 907/424-7511 • Fax: 907/424-7514
Website: www.pwsac.com • Email: pwsac@ak.net

As you can see, prior to the Department's action in February 1999 of removing the unused portion of permitted hatchery capacities statewide, the hatcheries within PWS were permitted for 788 million pink salmon eggs. Therefore, the requested combined pink salmon increases for the Armin F. Koernig (AFK), Wally Noerenberg (WNH), and Cannery Creek (CCH) hatcheries are within what has been previously permitted historically. A historical summary of the permitted capacity is outlined below for each of the three hatcheries. As you will recall, the Department committed to consider reinstating elements of the unused permitted capacity should PWSAC wish to in the future (see Attachment 2). As stated in the PAR applications and my previous letter, that time has come. With that, PWSAC requests reconsideration of the AFK, WNH, and CCH PARs based on the additional information provided below.

AFK

The AFK hatchery had been permitted for 190 million pink salmon eggs for a combined 11 years and placed that amount into production in three recent years (2003, 2005, and 2006). In 1992, just prior to construction of the new incubation building, the permitted capacity of the hatchery was increased from 150 to 190 million eggs (see Attachment 3). In 1999, as stated above, the unused portion of the permitted capacity was reduced from 190 to 160 million eggs. The permit was again increased back to 190 million eggs in 2003 as part of the Port Chalmers chum salmon program increase (see Attachment 4). Most recently in 2007, the permit was reduced from 190 to 162 million eggs to allow space for 17 million chum salmon eggs (see Attachment 5).

WNH

The WNH was originally permitted in 1983 for 211 million pink salmon eggs and held no less than that amount for 16 years (see Attachment 6). The permitted capacity has changed several times over the years with different pink and chum production combinations and a fixed number of incubators (see Attachment 7). The peak permitted capacity for pink salmon was 261 million eggs in 1989 (see Attachment 8).

CCH

The CCH was originally permitted for 147 million pink salmon eggs and 5 million chum salmon eggs in 1988 as PWSAC embarked on its management and operation of the facility for the State of Alaska (see Attachment 9). The chum salmon program was discontinued and converted to pink salmon production in 1989 due to chum salmon production problems outlined in Attachment 10. The production goal for the facility is 207 million pink salmon eggs.

Pink Salmon Fisheries Management

The Department describes its concerns in managing for wild stocks as 'very challenged', points to 'unavoidable harvest of wild stocks', and the susceptibility of 'numerous wild stock streams to localized depletion' that could occur during the hatchery return fisheries due to the location of the hatcheries and level of production. Two of the three (AFK and WNH) are described as located in primary wild stock migration corridors. This paints an overly bleak picture. Fortunately, our PWS pink salmon wild stocks are very healthy and have provided a sustainable yield to the commercial fishery roughly 80% of the time for nearly a hundred years. However, as the Department knows, the primary rationale for the hatchery system is that the industry is not sustainable if there is no available harvest in 20% of years. Therefore, notion that any harvest of wild stock pink salmon is unacceptable and should be avoided is shortsighted.

Also fortunate is that these considerations and others were taken into account to protect wild stocks as the PWS enhancement program and fishery management strategies for the hatchery returns were developed; specifically, with the creation of the hatchery subdistricts. As you know, the hatchery subdistricts were designed to harvest the highest concentration of surplus hatchery fish in the mixed stock fishery when wild stock interception must be minimized. These special management strategies are described annually in Section 3.5 of the Hatchery Annual Management Plans (see Attachment 11).

As the Department acknowledged, the minimum wild pink salmon sustainable escapement goal (SEG) has been exceeded in all years since it was established (2002) except in 2008[1]. During that same eight year period, the average combined pink salmon return for AFK, CCH, and WNH was 22.2 million fish. In fact, the combined total exceeded 25 million pink salmon in four out of the eight years and 30 million in three of those years (see Attachment 13). Therefore, it is silly to suggest that the Department's effectiveness in achieving escapement goals will be compromised in any way while harvesting hatchery returns greater than 15 million pink salmon.

Additionally, fishing time is identified as the principal tool used to manage the hatchery's return in the four designated approach zones to the AFK hatchery: the Point Elrington Subdistrict, the Port San Juan Subdistrict, the THA in outer Sawmill Bay, and the SHA in inner Sawmill Bay (see Attachment 11). The Department suggests that an increase in AFK pink salmon production will increase the risk of over-harvesting wild stock pink salmon and that fishing time may likely occur every other day or every third day rather than daily to allow escapement windows for wild stocks. Historically, commercial fishing periods every other day or every third day was the norm and PWSAC wholeheartedly supports escapement windows built into the fishery management strategy

[1] The 2008 season was indeed challenging with only 2.3 million wild stock pink salmon returning (just slightly above the SEG mid-point). However, the Department was successful in attaining an estimated escapement of 862,000. It is likely that the actual escapement was under-estimated given unfavorable observing weather in early September and inherent imprecision of the aerial survey method. Nonetheless, the 2008 season is a good example of the success of the pink salmon enhancement program, for without it, there would not have been a PWS pink salmon fishery as happened in 1973 and 1974 (see Attachment 12).

for both wild stocks and corporate escapement. Nevertheless, it is more likely that the Department's current strategy of fishing everyday (not only in the pink salmon fishery but also in the sockeye and chum salmon fisheries) poses a far greater risk of over-harvesting wild stocks than does the level of hatchery production.

Hatchery Salmon Straying

The Department provides an overview of the hatchery salmon straying impacts which has problems both in context and literature cited. And appears to reflect a bias held by some within the Department. The very use of the word 'deleterious' (in the first sentence of the first paragraph) is an example of the inappropriate use of normative language in resource conservation described by Lackey (2007) (see Attachment 14). Nearly all of, the literature cited speculates from theory about 'deleterious' effects, few of the references provide any empirical evidence; most likely because it is very difficult to find unequivocal evidence.

Araki et al. 2008: All of the studies forming the basis of their modeling exercise were on steelhead and coho salmon which, because they are cultured until they are smolt and are derived from small broodstocks, are most vulnerable to domestication, drift, and inbreeding. In contrast, pink and chum salmon (P&C) fry derived from very large broodstocks are unlikely to be so vulnerable and empirical studies of them have not shown evidence of domestication (e.g. Berejikian et al. 2009).

Naish et al. 2007: This is a very thorough review and includes many topics not related to straying. It is notable for its historical review and its review of the political context of hatcheries. Unfortunately, it does not review the political history of the Alaska/PWS enhancement program and it does not address the economic and social benefit context of Alaska/PWS enhancement programs to the people of Alaska.

Myers et al. 2007 (?): Ransom Myers died in 2007 and therefore did not publish on salmon then. Assuming the reference is to his 2004 Science article (Myers et al. 2004), it should be noted that it is an opinion piece in a Policy Forum on hatcheries and their use in sustaining endangered evolutionarily significant units (ESUs) -- a legal issue that was current at the time over whether the part of populations, particularly coho salmon in coastal Oregon, being propagated in conservation hatcheries should be legally considered as part of the census of the ESU. This is not really an issue in PWS. The article is not and does not pretend to be a review of the effects of straying by hatchery salmon. It presents no theoretical or empirical study of these issues. It refers to a few review papers, on species (European Atlantic salmon, coho salmon, and steelhead) not at issue in PWS.

Mobrand et al. 2005: This paper resulted from a large programmatic review of hatchery programs in Washington state, primarily of smolt species (unlike the PWS P&C hatchery program), primarily in hatcheries situated on rivers (unlike the PWS program), and characterized by many decades of naive practices of exotic stock transfer, small broodstocks, etc (unlike the PWS program). Regardless, this review took a constructive approach, identifying management strategies that would tend to allow natural selection to predominate over artificial selection in integrated populations.

Aprahamian et al. 2003: This is a review endorsing the use of hatcheries to sustain harvestability of Atlantic salmon in the British Isles. It is not particularly pertinent to PWS. It briefly reviews Pacific salmon but does not contribute any new theoretical or empirical information. However, it does indeed advocate an overt program of careful risk analysis.

Wang et al. 2002: This paper is an extensive review of inbreeding studies and is pertinent to the situation in PWS to the extent that the process of inbreeding contributes to the theoretically predicted development of genetic divergence between hatchery stocks from wild stocks. However, inbreeding is not likely an issue for these PARs as the P&C broodstocks are quite large and mated in a quasi 1:1 sex ratio.

Berejikian et al. 2001: They studied captive populations of coho salmon, in their case small populations that were cultured entirely through their lives and compared them to wild populations -- a worst-case-scenario study. It is not an appropriate model of the PWS P&C enhancement program.

Ford et al. 2006: This is a study of the Minter Creek coho salmon stock. Since the 1930s it has been almost entirely comprised of fish allowed past the weir in the lower creek, never managed for isolation, probably never a naturally producing population. This is another inappropriate model for PWS P&C enhancement program.

Wessel et al. 2006: This is a study of Chinook salmon that unlike PWS P&C salmon spend an extended part of their life cycle in artificial culture, were derived from very small broodstock collections from very small donor populations, and subject to founder effects. It is not an appropriate model for PWS P&C enhancement program.

McClelland et al. 2005: This is an experimental study of outbreeding depression in coho salmon. They demonstrated that it can be detected in hybridizations between genetically different populations. PWS hatchery broodstocks however are derived locally from within the region, and unless domestication effects have been radical, outbreeding depression will be minor.

Quinn et al. 2002: They reviewed the spawning dates of coho and Chinook salmon stocks at the University of Washington Hatchery for trends over time. Their conclusion was that the spawning dates for both species had become earlier due to hatchery practices of taking eggs only from early spawners. While not a novel observation, their findings support the longstanding PWSAC practice regarding egg-take practices. Again, this is not particularly pertinent as this source of artificial selection is overtly avoided in PWS hatchery practice and is unlikely given the large scale of the P&C egg-takes and broodstocks.

Quinn et al. 2007: This is a paper on likely effects of climate change and on the density effects on fitness in spawning populations. The Department's implication in the subject memo is that their study is on density exacerbated by hatchery strays – it is not. The focus was on the Alagnak River system during the exceptionally large sockeye salmon escapements in 2004 and 2005.

Quinn 2005: This is part of his textbook chapter discussing the density relationships of spawning success in natural populations of salmon. The Department's implied notion is that if straying salmon are present simultaneously with wild salmon on the spawning grounds the straying salmon could diminish the wild salmon fitness simply by being present and interacting behaviorally. There is no empirical evidence of such an interaction between hatchery and wild salmon.

Hilborn and Eggers 2000: This paper was largely discredited by a series of papers in the literature by Wertheimer and his colleagues. It is distressing that the Department takes such a biased view of the literature that they do not acknowledge the published evidence contrary to this paper (Wertheimer et al. 2001, 2004a, 2004b). Indeed, for the Department to state outright that; "we believe that the straying of hatchery salmon into wild stock streams, and ensuing ecological and genetic interactions of wild and hatchery stocks, may be responsible for this replacement [of wild salmon by hatchery produced salmon in PWS]" in the absence of any empirical evidence of such a replacement and without acknowledging published literature discounting the paper is disconcerting.

Hatchery Salmon Straying Threshold and Genetics

The Department continues to struggle in its efforts to define an acceptable straying threshold and uses the literature for guidance: 2% (PWS/CR phase 3 plan 1994), 5% (Mobrand et al. 2005), and 10% (Ford 2002). Unfortunately, however, these modeling exercises are limited to the assumptions placed into them and, as we have explained, most have no similarity to the Alaska/PWS enhancement program.

The Department describes its findings from their limited pink salmon otolith samples recovered in streams across PWS as "high rates of straying" of hatchery fish and a cause for alarm. However, significant straying, especially with pink salmon, is not a new observation for the Department.

Jones and Thomason (1984) documented wild stock adult pink salmon straying from 10 of 12 tagging locations and observed their strong propensity to move between streams in

Southern Southeast Alaska. Interestingly, they recovered strays as far away as 40 miles from their Vallenar Creek tagging location on Gravina Island.

Sharp et al. (1994) documented wild stock straying rates that averaged 25% and ranged from 9 – 53% in western PWS based on recoveries of coded-wire tagged (CWT) adult pink salmon marked as fry emigrating from six natal streams. Like Jones and Thomason (1984), they also documented recovering wild stock strays at considerable distances away from their natal streams. In particular, they recovered tagged wild stock pink salmon from Totemoff Creek at streams in eastern PWS over 60 miles away. They also noted interesting patterns in straying behavior, one of which was that particular streams tended to attract multiple strays, both of wild and hatchery origin, while other nearby streams did not.

Habicht et al. (1998) called into question the observation of high straying rates by Sharp et al. (1994). They investigated the CWT placement in pink salmon fry and its affects on homing ability and in one year found a correlation suggesting that poor placement of CWTs induced straying, but did not find such a correlation in another year. Mortensen et al. (2002) however, found no effect on straying associated with CWT tagging in pink salmon.

Joyce and Evans (1999) found while comparing the relative precision between hatchery contribution estimates from the CWT and thermal otolith marking programs that the proportion of pink salmon from AFK and WNH in stream escapements was highly correlated with distance of the stream from the facility. They also found a lower number of detected strays of CCH pink salmon and suggested that a distance-straying frequency relationship may also exist for CCH pink salmon and that the CCH stock may home more effectively.

Pink salmon have a widespread reputation for straying at higher rates than other species of Pacific Salmon. As Hard et al. (1996) points out, pink salmon have the unusual ability to expand into suitable habitat when conditions are favorable. In their review, they also suggest that levels of natural straying may vary widely among populations and within populations under different conditions and may depend strongly on spawning location and on conditions at time of spawning. They suggested that several factors may contribute to the relatively high straying observed in PWS: 1) PWS is a highly dynamic geological zone, having experienced two major earthquakes in the last century that destroyed many streams and created others; 2) a large fraction (~75%) of PWS pink salmon spawn intertidally; and 3) the southwestern part of PWS was heavily affected by the 1989 *Exxon Valdez* oil spill.

However, Wertheimer et al. (2000) investigated the effects of oil exposure on pink salmon homing and concluded that their results did not support the hypothesis that oil exposure of embryos in intertidal spawning grounds was responsible for the high rates of straying of wild stock pink salmon observed in PWS after the *Exxon Valdez* oil spill. They suggested that, more likely, the high straying rates in PWS may represent an adaptation that is designed to buffer a population that does not have age structure[2] from catastrophic failure in an unstable environment and that pink salmon incubating and emerging in intertidal stream reaches may have intrinsically higher stray rates because of the short exposure time available for imprinting to the freshwater of the natal stream following emergence from the gravel.

Seeb et al. (1999) investigated allozyme and mitochondrial DNA variation to describe the ecological important genetic structure of even-year pink salmon inhabiting PWS. They obtained data in 1994 from pink salmon throughout PWS; two hatcheries (AFK and Solomon Gulch Hatchery (SGH)), five upstream, and 20 tidal locations distributed among the five management regions. They detected a relatively shallow degree of genetic structuring limited to distinctions between upstream and tidal spawners. Interestingly, they found a greater dissimilarity among the five upstream collections than among the 20 tidal collections and concluded that the regional divergence found only in the upstream spawners suggests greater isolation and possible adaptive specialization among some of the populations. Conversely, they concluded that the detectable heterogeneity among tidal collections indicate greater gene flow among tidal spawners. This may confirm the occurrence of significant straying among the tidal spawners. In regards to the AFK pink salmon, they found that the AFK fish (and the WNH fish as they are of the same brood source) were not distinct from tidal spawners from the other management regions.

The Department suggests that the hatchery pink salmon broodstocks are essentially closed to gene flow from the wild stocks. This may be the case in some years, especially when wild stock escapement is low, as in 2008, but a closer review of the available data reveals that it can be quite substantial at times (Sharr et al. 1995 and Sharp et al. 1994). Indeed, the data collected by PWSAC in 2009, suggests that approximately 212, 143, and 179 wild stock pink salmon contributed to the hatchery broodstocks (AFK, CCH, and WNH, respectively). This represents an increase from 2008 but these are only two data points from our newly created broodstock monitoring program. Most likely, the wild stock contribution to the hatchery broodstocks increase as the wild stock escapements increase. Seeb et al. (1999) highlights the importance that hatchery stocks be developed and maintained with local stocks. Therefore, if the Department continues to have concerns, it may be prudent to develop criteria in which adequate contributions of wild stocks are brought into the hatchery broodstocks from the original local donor stocks via remote egg collections periodically.

---

[2] PWS pink salmon have a fixed 2-year life history and the progeny of a given brood year mature all at the same age.

Density Dependent Survival and Growth

The Department's comments and concerns range from inter and intra-specific food resource competition (nearshore and offshore waters of the North Pacific Ocean), reduced production of sockeye salmon in Bristol Bay, and a connection to the crash and lack of recovery of PWS herring.

Food Resource Competition – Nearshore (PWS)

The Department states that the study of Cooney (1993) has been erroneously cited as evidence that carrying capacity in PWS has not been reached for juvenile pink salmon. It is unclear what the Department is implying with this statement. Cooney (1993) evaluated theoretical estimates of primary/secondary production and production of macrozooplankton and compared them to estimates of salmon fry forage demand. He concluded that that present levels (1.2 billion juveniles, hatchery and wild stocks) salmon feeding have a minimal impact on zooplankton stocks in PWS.

A better understanding of this topic comes from the comprehensive collaborative work of the Sound Ecosystem Assessment project of which the Department was a partner. Cooney et al. (2001) provides an overview of the ecosystem controls of juvenile pink and Pacific herring populations in PWS. They found that juvenile pink salmon and age-0 herring exploit very different portions of the annual production cycle. In that, juvenile pink salmon targeted the cool-water early spring plankton bloom and the age-0 herring are dependent on warmer conditions that occurred later in the post-bloom summer and fall. They also concluded that even using liberal first-order estimates of consumption of zooplankton by juvenile pink salmon, herring, and other age-0 fishes was insufficient to account for but a portion of the estimated zooplankton produced each year.

Boldt and Haldorson (2002) used a bionergetics approach to estimate consumption by juvenile pinks in PWS and concurred with Cooney (1993) that consumption by pink fry was less than 1% of annual copepod production in PWS and less than 20% of localized standing stocks of copepods and amphipods. Cross et al (2005) continued that research and studied PWS pink fry in another year (2001 vs 1998) and found that consumption was significantly larger and that appeared to exceeded standing stock of some key prey but they point out several limitations of their work "before we can determine if ecological bottlenecks on salmon growth exist in Prince William Sound and the coastal Gulf of Alaska" including their inability to measure prey production rather than standing stock and their study's sampling bias (low) in estimating prey biomass/standing stock. They found that hatchery and wild pink salmon had similar, high, growth efficiencies but that wild pink salmon, by emigrating earlier to the Gulf of Alaska consumed more and grew faster than hatchery fry.

Food Resource Competition – Offshore (North Pacific Ocean)

The Department cites Werthheimer et al. (2004b) and focuses attention on their estimated annual wild-stock yield loss. A more thorough reading of their study reveals that their estimates of the upper limit on yield loss represents less than 5% of the average annual hatchery returns and they estimated a resultant net gain from the hatchery production as 23.2 million fish per year, a vital part of the economic productivity of the fishery. Werthheimer et al. (2004b) also concluded that hatchery releases did not explain significant variation in body size at return when considered in the context of other biophysical factors such as the abundance of pink salmon in the Gulf of Alaska.

The Department implies that these pink salmon production increases will somehow be the tipping point in the North Pacific Ocean and will result in decreased growth, survival, and run sizes for Chinook, chum, and sockeye salmon. However, when placed into context, these increases (95 million pink salmon fry) will only represent a 2% increase to the hatchery production of ~4950 million juvenile salmon that are released annually into the North Pacific (Irvine et al. 2009). Irvine et al. (2009) also report that following the 1977 regime shift, salmon catches increased until the early to mid-1990's and since the 1989 shift have remained relatively stable (see Attachment 15). They concluded that "based on these data, since aggregate catches of all species are at or near all time highs with no indication of declines, it appears that Pacific salmon at the scale of the North Pacific are doing well."

PWS Herring

The Department cites Pearson et al. (1999) and Deriso et al. (2008) as the foundation for their concerns regarding the crash and lack of recovery of the PWS herring. This is indeed unfortunate and outright offensive given that the former paper, a review of alternative hypotheses funded by Exxon Company, has been widely discounted as it tried to argue that the evidence regarding the 1993 PWS herring declined resulted from a combination of natural factors rather than the *Exxon Valdez* oil spill.

Deriso et al. (2008) is a modeling exercise that incorporates covariates into a fisheries stock assessment model and is based on Pearson et al. (1999) and data presented in Sturdevant (1999), Willette et al. (2001), and Cross et al. (2005). Specifically, Deriso et al. (2008) states that "a few limited studies indicate juvenile pink salmon interactions could be affecting juvenile herring through food competition with the age-1 herring and predation on the age zero." However, none of the three referenced studies offer any empirical data suggesting that juvenile pink salmon prey upon age-0 herring. This is most likely due to the fact that juvenile pink salmon consume less than 1% 'fish' during their time in PWS (April-July) (Sturdevant 1999).

Conversely, Willette et al. (2001) identified nine taxonomic groups of piscivore fishes and several piscivore seabird species in PWS and estimated that combined they consumed about 546 million juvenile salmon during the first 45 days of their sea life in

PWS. They estimate that these predation losses represented about 75% of the approximately 726 million juveniles that enter PWS. They estimated that of the fishes, herring consumed the second greatest amount of juvenile salmon in PWS during the months of May and June, second only to the category of 'other gadids.'

More likely, the consumption of herring by marine mammals as described by Thomas and Thorne (2001) and Moran (2009) is a far greater factor in the lack of recovery of the PWS herring stock than juvenile pink salmon (see Attachments 16 and 17).

In summary, while the Department may have some reservations in reinstating the pink salmon permitted capacities there is ample evidence suggesting that the PWS wild pink salmon stocks are being managed and protected well by Alaska's enhancement policies (genetics, pathology, etc.) established at the onset of the programs.

PWSAC appreciates the Department's efforts in reviewing these PARs carefully to ensure the success and sustainability of the salmon resources and fisheries within PWS. As you know, PWSAC has been a good corporate citizen, actively encouraging and supporting ecological research in PWS since the early 1970's. We look forward to discussing these topics further at the upcoming Prince William Sound / Copper River Regional Planning Team meeting.

Sincerely,

David Reggiani
General Manager

Cc: Tim Joyce, PWS/RPT Chairman
John Hilsinger, Division of Commercial Fisheries Director
Charlie Swanton, Division of Sport Fish Director
Sue Aspelund, Division of Commercial Fisheries Deputy Director

Literature Cited

Aprahamian, M. W., K. M. Smith, P. McGinnity, S. McKelvey, and J. Taylor. 2003. Restocking of Salmonids—Opportunities and Limitations. Fisheries Research 62: 211-227.

Araki, H., B. A. Berejikian, M. J. Ford, and M. S. Blouin. 2008. Fitness of Hatchery-Reared Salmonids in the Wild. Evolutionary Applications 1(2): 342-355.

Berejikian, B. A., E. P. Tezak, L. Park, E. LaHood, S. L. Schroder, and E. Beall. 2001. Male Competition and Breeding Success in Captively Reared and Wild Coho Salmon (Oncorhynchus kisutch). Canadian Journal of Fisheries and Aquatic Science 58: 804-810.

Berejikian, B. A., D. M. Van Doornik, J. A. Scheurer, and R. Bush. 2009. Reproductive Behavior and Relative Reproductive Success of Natural- and Hatchery-origin Hood Canal Summer Chum Salmon (*Oncorhynchus keta*). Canadian Journal of Fisheries and Aquatic Science 66: 781-789.

Boldt, J. L. and L. J. Haldorson. 2002. A Bionergetics Approach to Estimating Consumption of Zooplankton by Juvenile Pink Salmon in Prince William Sound, Alaska. Alaska Fishery Research Bulletin 9(2): 111-27.

Cooney, R. T. 1993. A Theoretical Evaluation of the Carrying Capacity of Prince William Sound, Alaska, for Juvenile Pacific Salmon. Fisheries Research 18: 77-87.

Cooney, R. T., J. R. Allen, M. A. Bishop, D. L. Eslinger, T. Kline, B. L. Norcross, C. P. McRoy, J. Milton, J. Olsen, V. Patrick, A. J. Paul, D. Salmon, D. Scheel, G. L. Thomas, S. L Vaughan, and T. M. Willette. 2001. Ecosystem Controls of Juvenile Pink Salmon (*Onchorynchus gorbuscha*) and Pacific herring (*Clupea pallasi*) populations in Prince William Sound, Alaska. Fisheries Oceanography 10 (Supplement 1): 1-13.

Cross, A. D., D. A. Beauchamp, J. L. Armstrong, M. Blikshteyn, J. L. Boldt, N. D. Davis, L. J. Haldorson, J. H. Moss, K. W. Myers, and R. V. Walker. 2005. Consumption Demand of Juvenile Pink Salmon in Prince William Sound and the Coastal Gulf of Alaska in Relation of Prey Biomass. Deep-Sea Research II 52: 347-370.

Deriso, R. B., M. N. Maunder, and W. H. Pearson. 2008. Incorporating Covariates into Fisheries Stock Assessment Models with Application to Pacific Herring. Ecological Applications 18(5): 1270-1286.

Ford, M. J. 2002. Selection in Captivity during Supportive Breeding May Reduce Fitness in the Wild. Conservation Biology 16(3): 815-825.

Ford, M. J., H. Fuss, B. Boelts, E. LaHood, J. Hard, and J. Miller. 2006. Changes in Run Timing and Natural Smolt Production in a Naturally Spawning Coho Salmon (Oncorhynchus kisutch) Population after 60 Years of Intensive Hatchery Supplementation. Canadian Journal of Fisheries and Aquatic Science 63: 2343-2355.

Habicht, C., S. Sharr, D. Evans, and J. E. Seeb. 1998. Coded Wire Tag Placement Affects Homing Ability of Pink Salmon. Transactions of the American Fisheries Society 127: 652-657.

Hard, J. J., R. G. Kope, W. S. Grant, F. W. Waknitz, L. T. Parker, and R. S. Waples. 1996. Status Review of Pink Salmon from Washington, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-25, 131p.

Hilborn, R. and D. Eggers. 2000. A Review of the Hatchery Programs for Pink Salmon in Prince William Sound and Kodiak Island, Alaska. Transactions of the American Fisheries Society 129: 333-350.

Irvine, J. R., M. Fukuwaka, T. Kaga, J. H. Park, K. B. Seong, S. Kang, V. Karpenko, N. Klovach, H. Bartlett, and E. Volk. 2009. Pacific Salmon Status and Abundance Trends. NPAFC Doc. 1199, Rev. 1. 153 pp.

Jones, J. D. and G. Thomason. 1984. U.S./Canada Salmon Stock Interception Research Southern Southeastern Alaska Pink Salmon (Oncorhynchus gorbuscha) Tagging Study, 1982. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet No. 231, Juneau, Alaska.

Joyce, T. L. and D. G. Evans. 1999. Otolith Marking of Pink Salmon in Prince William Sound Salmon Hatcheries, *Exxon Valdez* Oil Spill Restoration Final Report (Restoration Project 99188), Alaska Department of Fish and Game, Division of Commercial Fisheries, Cordova and Anchorage, Alaska.

McClelland, E. K., J. M. Myers, J. J. Hard, L. K. Park, and K. A. Naish. 2005. Two Generations of Outbreeding in Coho Salmon (Oncorhynchus kisutch): Effects on Size and Growth. Canadian Journal of Fisheries and Aquatic Science. 62: 2538-2547.

Mobrand, L. E., J. Barr, L. Blankenship, D. E. Campton, T. T. P. Evelyn, T. A. Flagg, C. V. W. Mahnken, L. W. Seeb, P. R. Seidel, and W. W. Smoker. 2005. Hatchery Reform in Washington State: Principles and Emerging Issues. Fisheries 30(6): 11-39.

Moran, J. 2009. Humpback Whales in Seymour Canal, Southeast Alaska: Numbers and Forage Base. Alaska Fisheries Science Center Quarterly Research Reports Oct-Dec 2009: 10.

Mortensen, D. G., A. C. Wertheimer, J. M. Maselko, and S. G. Taylor. 2002. Survival Straying of Auke Creek, Alaska, Pink Salmon Marked with Coded Wire Tages and Thermally Induced Otolith Marks. Transactions of the American Fisheries Society 131: 14-26.

Myers, R. A., S. A. Levin, R. Lande, F. C. James, W. W. Murdoch, and R. T. Paine. 2004. Hatcheries and Endangered Salmon. Science 303: 1980.

Naish, K. A., J. E. Taylor, III, P. S. Levin, T. P. Quinn, J. R. Winton, D. Huppert, and R. Hilborn. 2007. An Evaluation of the Effects of Conservation and Fishery Enhancement Hatcheries on Wild Populations of Salmon. Advances in Marine Biology 53:61-194.

Pearson, W. H., R. A. Elston, R. W. Bienert, A. S. Drum, and L. D. Antrim. 1999. Why did the Prince William Sound, Alaska, Pacific Herring (*Clupea pallasi*) Fisheries Collapse in 1993 and 1994? Review of Hypotheses. Canadian Journal of Fisheries and Aquatic Sciences 56: 711-737.

PWS/CR RPT (Prince William Sound/Copper River Regional Planning Team). 1994. Prince William Sound/Copper River Phase 3 Comprehensive Salmon Plan. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage, Alaska.

Quinn, T. P., J. A. Peterson, V. F. Gallucci, W. K. Hershberger, and E. L. Brannon. 2002. Artificial Selection and Environmental Change: Countervailing Factors Affecting the Timing of Spawning by Coho and Chinook Salmon. Transactions of the American Fisheries Society 131: 591-598.

Quinn, T. P. 2005. Mating Systems and Reproductive Success. The Behavior and Ecology of Pacific Salmon & Trout. Bethesda, Maryland/Seattle, Washington, American Fisheries Society/University of Washington Press: 105-128.

Quinn, T. P., D. M. Eggers, J. H. Clark, and H. B. Rich, Jr. 2007. Density, Climate, and the Processes of Prespawning Mortality and Egg Retention in Pacific Salmon (Oncorhynchus Spp.). Canadian Journal of Fisheries and Aquatic Science 64: 574-582.

Seeb, J. E., C. Habicht, W. D. Templin, L. W. Seeb, J. B. Shaklee, and F. M. Utter. 1999. Allozyme and Mitochondrial DNA Variation Describe Ecologically Important Genetic Structure of Even-Year Pink Salmon Inhabiting Prince William Sound, Alaska. Ecology of Freshwater Fish 8: 122-140.

Sharp, D., S. Sharr, and C. Peckham. 1994. Homing and Straying Patterns of Coded Wire Tagged Pink Salmon in Prince William Sound. In Proceedings 16th Northeast Pacific Pink and Chum Salmon Workshop, Alaska Sea Grant College Program Report 94-02: 77-82.

Sharr, S., C. J. Peckham, D. G. Sharp, and B. G. Bue. 1995. Coded Wire Tag Recoveries from Pink Salmon in Prince William Sound Salmon Fisheries, 1993. *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 93067), Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Anchorage, Alaska.

Sturdevant, M. V. 1999. Forage Fish Diet Overlap, 1994-1996. *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 97163C), Auke Bay Laboratory, National Marine Fisheries Service, Juneau, Alaska.

Thomas, G. L. and R. E. Thorne. 2001. Night-time Predation by Steller Sea Lions. Nature 411: 1013.

Wang, S., J. Hard, and F. Utter. 2002. Salmonid Inbreeding: A Review. Reviews in Fish Biology and Fisheries 11: 301-319.

Wertheimer, A. C., R. A. Heintz, J. F. Thedinga, J. M. Maselko, and S. D. Rice. 2000. Straying of Adult Pink Salmon from their Natal Stream following Embryonic Exposure to Weathered *Exxon Valdez* crude oil. Transactions of the American Fisheries Society 129: 989-1004.

Wertheimer, A. C., W. W. Smoker, T. L. Joyce, and W. R. Heard. 2001. Comment: A Review of the Hatchery Programs for Pink Salmon in Prince William Sound and Kodiak Island, Alaska. Transactions of the American Fisheries Society 130: 712-720.

Wertheimer, A. C., W.W. Smoker and W. R. Heard. 2004a. Effects of hatchery releases and environmental variation on wild-stock productivity: consequences for sea ranching of pink salmon in Prince William Sound, Alaska. Chapter 23, pp 307-326 In K. M. Leber, S. Kitada, T. Svasand & H. L. Blankenship, editors. Stock Enhancement and Sea Ranching 2d Edition, Blackwell Science Ltd, Oxford.

Werthheimer, A. C., W. R. Heard, J. M. Maselko, and W. W. Smoker. 2004b. Relationship of Size at Return with Environmental Variation, Hatchery Production, and Productivity of Wild Pink Salmon in Prince William Sound, Alaska: Does Size Matter?. Reviews in Fish Biology and Fisheries 14: 321-334.

Wessel, M. L., W. W. Smoker, R. M. Fagen, and J. Joyce. 2006. Variation of Agonistic Behavior Among Juvenile Chinook Salmon (Oncorhynchus tshawytscha) of Hatchery, Hybrid, and Wild Origin. Canadian Journal of Fisheries and Aquatic Science 63: 438-447.

Willette, T. M., R. T. Cooney, V. Patrick, D. M. Mason, G. L. Thomas and D. Scheel. 2001. Ecological Processes Influencing Mortality of Juvenile Pink Salmon (*Oncorhynchus gorbuscha*) in Prince William Sound, Alaska. Fisheries Oceanography 10 (Supplement1): 14-41.

Attachment 1.

Prince William Sound PNP Permit Summary - 1998

	PNP Number	Issue Date	Species	Permit	Actual	Unused Portion	Comments
PWSAC							
Armin F. Koernig Hatchery	2	1975	Pink	190,000,000	160,000,000	30,000,000	
			Chum	13,000,000	-	13,000,000	Program discontinued in 1998
Wally Noerenberg Hatchery	20	1985	Pink	211,000,000	150,000,000	61,000,000	
			Chum	122,000,000	111,000,000	11,000,000	
			Sockeye	31,000,000	-	31,000,000	Program discontinued in 1989
			Coho	4,000,000	1,600,000	2,400,000	
			Chinook	4,000,000	-	4,000,000	Program discontinued in 1998
Cannery Creek Hatchery	26	1988	Pink	147,000,000	152,000,000	(5,000,000)	
			Chum	5,000,000	-	5,000,000	Program discontinued in 1989
Main Bay Hatchery	No Permit **	n/a	Sockeye	10,325,000	10,325,000	-	
Gulkana Hatchery	No Permit **	n/a	Sockeye	35,000,000	35,000,000	-	
VFDA							
Solomon Gulch Hatchery	15	1981	Pink	230,000,000	230,000,000	-	
			Chum	18,000,000	-	18,000,000	Program discontinued in 1995
			Coho	2,000,000	2,000,000	-	
			Chinook	300,000	-	300,000	Program discontinued in 1992
NERKA, Inc.							
Perry Island Hatchery	1	1975	Pink	10,000,000	-	10,000,000	Not used since 1982
			Chum	10,000,000	-	10,000,000	
TOTAL PWS			Pink	788,000,000	692,000,000	96,000,000	
			Chum	168,000,000	111,000,000	57,000,000	
			Sockeye **	76,325,000	45,325,000	31,000,000	
			Coho	6,000,000	3,600,000	2,400,000	
			Chinook	4,300,000	-	4,300,000	
			Grand Totals	**1,042,625,000**	**851,925,000**	**190,700,000**	

** Basic Management Plans for the Main Bay Hatchery and Gulkana Hatchery are still outstanding. These projects are permitted under the ADF&G contract.

ATTACHMENT 2.

STATE OF ALASKA

TONY KNOWLES, GOVERNOR

DEPARTMENT OF FISH AND GAME

OFFICE OF THE COMMISSIONER

P.O. BOX 25526
JUNEAU, ALASKA 99802-5526
PHONE: (907) 465-4100
FACSIMILE: (907) 465-2332

February 8, 1999

Bud Perrine, General Manager
Prince William Sound Aquaculture Corporation
P.O. Box 1110
Cordova, AK 99574

Dear Mr. Perrine:

Please find enclosed approved notices of permit alterations for the Wally Noerenberg, Armin F. Koernig, and Cannery Creek hatcheries that adjust the permitted capacities for these facilities to the new levels negotiated with the Prince William Sound/Copper River Regional Planning Team and the department last spring. The new permitted capacities more accurately reflect the actual production capabilities of the hatcheries, and they more closely fit the Prince William Sound Aquaculture Corporation's (PWSAC) production goals for the foreseeable future. The permitted capacity at the Armin F. Koernig Hatchery has been reduced from 190 million pink salmon eggs to 160 million pink salmon eggs and the previously permitted increment of 11 million chum salmon eggs has been removed. The permitted capacity for pink salmon at Wally Noerenberg Hatchery has been reduced from 211 million eggs to 150 million eggs and the unused increment of 31 million sockeye salmon eggs has been deleted. The permitted capacity for pink salmon at Cannery Creek Hatchery has been increased from 147 million to 152 million eggs and the corresponding increment of 5 million chum salmon eggs has been deleted from the permit. If PWSAC's plans for these hatcheries change again in the future, the department is willing to consider additional permit alteration requests to maintain the flexibility PWSAC needs to be successful.

Please remember that approval by the Alaska Department of Fish and Game (ADF&G) to conduct the activities described in this permit alteration does not imply agreement by ADF&G or the Department of Commerce and Economic Development to commit state or federal monies or state loan funds for the project, nor does it absolve PWSAC from obtaining all other state, federal, and local permits necessary for the permitted activities.

If you have any questions regarding this matter, please contact Steve McGee of the Private Nonprofit Hatchery Program at 465-6152.

Sincerely,

Robert Bosworth
Deputy Commissioner

Enclosures

cc: PWS/CR RPT
Steve McGee

ATTACHMENT 3.

Alaska Department of Fish and Game

PRIVATE NONPROFIT SALMON HATCHERY

PERMIT NO. 2

NOTICE OF PERMIT ALTERATION

This notice, in conjunction with the original private nonprofit hatchery permit for the Port San Juan Hatchery (aka Armin F. Koernig Hatchery), allows an increase in production of pink salmon of 40 million eggs annually. The maximum permitted capacity of the hatchery is now 190 million pink salmon eggs and 13 million chum salmon eggs.

As a condition of approval, Prince William Sound Aquaculture Corporation (PWSAC) must be prepared to develop and fund a departmentally approved evaluation program for the new increment of production to determine inseason contributions of hatchery-produced fish to common-property fisheries in Prince William Sound.

All other conditions of the permit remain as stated in the original permit, dated September 29, 1975, and its subsequent alterations.

C Meacham for
Carl L. Rosier
Commissioner

4-13-92
Date

ATTACHMENT 4.

Alaska Department of Fish and Game
Private Nonprofit Salmon Hatchery

Permit No. 2

Notice of Permit Alteration

This notice, in conjunction with the original Private Nonprofit salmon hatchery permit for the Armin F. Koernig Hatchery, increases the permitted capacity for pink salmon by 30 million eggs from 160 million to 190 million eggs. This increase in capacity is commensurate with a decrease of 30 million eggs in the permitted capacity at the Wally Noerenberg Hatchery. All resultant fry from this increase in production will be released at the hatchery site in Port San Juan.

All other conditions of the permit remain as stated in the original permit for the Armin F. Koernig Hatchery, dated September 29, 1975, and in its subsequent alterations.

David Bedford
Deputy Commissioner

5/21/2003
Date

STATE OF ALASKA

FRANK H. MURKOWSKI
GOVERNOR

DEPARTMENT OF FISH AND GAME

Division of Commercial Fisheries

P.O. BOX 25526
JUNEAU, AK 99802-5526
PHONE: (907) 465-4100
FAX: (907) 465-2332

May 23, 2003

Dave Reggiani
General Manager
Prince William Sound Aquaculture Corporation
P.O. Box 1110
Cordova, AK 99574

Dear Dave:

Please find enclosed approved notices of permit alterations that allow the Prince William Sound Aquaculture Corporation (PWSAC) to (1) increase pink salmon production at the Armin F. Koernig Hatchery by 30 million eggs, (2) reduce the permitted capacity for pink salmon at the Wally Noerenberg Hatchery by 30 million eggs, and (3) increase chum salmon production at the Wally Noerenberg Hatchery by 37 million eggs, with resulting fry to be released at Port Chalmers and at Port San Juan.

Please remember that approval by the Alaska Department of Fish and Game (ADF&G) to conduct the activities described in this permit alteration does not imply agreement by ADF&G or the Department of Commerce and Economic Development to commit state or federal monies or state loan funds for the project, nor does it absolve PWSAC from obtaining all other state, federal and local permits necessary for the project, including Fish Transport Permits to allow the transport and release of specific stocks of fish for the projects.

If you have any questions regarding this permit alteration, please contact me at 465-6152.

Sincerely,

Steve McGee

Steve McGee
Development Program Manager

Enclosure

ATTACHMENT 5.

Alaska Department of Fish and Game

Private Nonprofit Salmon Hatchery

Permit No. 2

Notice of Permit Alteration

This notice, in conjunction with the original Private Nonprofit salmon hatchery permit for the Port San Juan Hatchery, now the Armin F. Koernig Hatchery (AFK) operated by the Prince William Sound Aquaculture Corporation (PWSAC), decreases the capacity for pink salmon from 190 million to 162 million green eggs, and establishes the capacity for chum salmon at 17 million green eggs.

All other conditions of the hatchery permit remain as stated in the original permit and Basic Management Plan for AFK, and in its subsequent alterations.

David Bedford
Deputy Commissioner

6/15/07
Date

ATTACHMENT 6.

Alaska Department of Fish & Game

PRIVATE NONPROFIT SALMON HATCHERY PERMIT NO. 20

Permission is hereby granted to Prince William Sound Aquaculture Corporation, P.O. Box 1110, Cordova, Alaska 99574, hereinafter called the permittee, to construct and operate a salmon hatchery facility located at Lake Bay on Esther Island, 60°47' N. Latitude, 148°5' W. Longitude.

The hatchery shall be operated in accordance (1) with AS 16.10.400-470; (2) with any regulations promulgated by the Department of Fish and Game or the Board of Fisheries (including those adopted after issuance of this permit); and (3) with the Alaska Department of Fish and Game Statement of Policy on Permitting Nonprofit Salmon Hatcheries in Alaska, dated October 3, 1974.

Specific conditions which must be met in the operation of the salmon hatchery are described below and attached in Conditions 1 through 11 and in the Basic Management Plan for Esther Lake Hatchery.

If the permittee fails to comply with the terms of this permit within a reasonable period of time after notification of noncompliance, the permit will be suspended or revoked.

No more than 211,000,000 pink salmon eggs, 111,000,000 chum salmon eggs, 1,000,000 coho salmon eggs and 1,000,000 chinook salmon eggs may be taken for incubation in any one year. Requested donor streams are listed below. Donor streams to be used will be finalized through Fish Transport Permits approved by the Department. Additions to or changes in approved streams and number of eggs which can be taken may be made by the Department at any time.

SPECIES Pink Salmon (Oncorhyncus gorbuscha)	Stream No.	SPECIES Chum salmon (Oncorhyncus keta)	Stream No.
Koppen Creek	(221-20-035)	Koppen Creek	(221-20-035)
Wells River	(222-20-234)	Wells River	(222-20-234)
Coghill River	(223-30-322)	Coghill River	(223-30-322)
Shrode Creek	(224-30-476)	Sunny River	(221-40-087)
P. San Juan Hatchery			
Alternates		Alternates	
Beartrap Creek	(221-30-048)	Beartrap Creek	(221-30-048)
Olsen Creek	(221-30-051)	Olsen Creek	(221-30-051)
Indian Creek	(221-50-117)	Indian Creek	(221-50-117)

SPECIES Chinook salmon (Oncorhynchus tshawytscha)	SPECIES Coho Salmon (Onchorhynchus kisutch)	Stream No.
Crooked Creek (ADF&G Facility) or Copper River	Corbin Creek or Copper River	(221-60-137)

The duration of this permit is unlimited unless the operation is found to be contrary to AS 16.10.420-430 or to any condition of this permit. That portion of this permit which describes the number of salmon eggs of any species which may be taken for incubation and the location from which the eggs are taken as well as any other condition of the permit will be subject to annual review and amendment by the Department.

Don W. Collinsworth | 6-17-83

Don W. Collinsworth
Commissioner
Alaska Department of Fish and Game

Date

ATTACHMENT 7.

PWSAC Historic Production Summary

Hatchery	WNH

Sum of Green Eggs	Species		
Brood Year	Chum	Pink	Grand Total
1983	21,560,438		21,560,438
1984	16,801,595		16,801,595
1985	17,393,190	53,593,141	70,986,331
1986	40,181,541	78,909,893	119,091,434
1987	82,637,512	207,953,763	290,591,275
1988	101,500,872	180,262,542	281,763,414
1989	53,359,960	269,624,688	322,984,648
1990	85,298,403	240,097,347	325,395,750
1991	113,196,809	180,470,137	293,666,946
1992	112,427,380	184,752,082	297,179,462
1993	111,200,784	180,559,831	291,760,615
1994	109,164,711	188,110,652	297,275,363
1995	111,213,387	188,506,249	299,719,636
1996	110,336,443	115,818,276	226,154,719
1997	111,281,591	110,288,679	221,570,270
1998	111,129,724	130,197,003	241,326,727
1999	111,010,849	130,003,972	241,014,821
2000	81,922,013	131,267,684	213,189,697
2001	114,083,514	119,081,166	233,164,680
2002	115,637,488	132,655,040	248,292,528
2003	151,526,806	119,361,534	270,888,340
2004	148,419,530	94,862,542	243,282,072
2005	167,770,221	96,333,418	264,103,639
2006	170,000,000	91,800,000	261,800,000
2007	130,000,000	148,000,000	278,000,000
2008	130,600,000	148,000,000	278,600,000
2009	132,000,000	148,000,000	280,000,000

ATTACHMENT 8.

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

OFFICE OF THE COMMISSIONER

STEVE COWPER, GOVERNOR

P.O. BOX 3-2000
JUNEAU, ALASKA 99802-2000
PHONE: (907) 465-4100

August 25, 1989

PRINCE WILLIAM
SOUND AQUACULTURE
SEP - 8 1989

Mr. Bruce Suzumoto
President
Prince William Sound
Aquaculture Corporation
P.O. Box 1110
Cordova, AK 99574

Dear Mr. Suzumoto:

Please find enclosed an approved notice of permit alteration that allows the Prince William Sound Aquaculture Corporation (PWSAC) to temporarily increase production of pink salmon at the Esther Lake hatchery in order to take advantage of incubation capacity left empty by a shortage of chum salmon eggs. Up to 261 million pink salmon eggs may be taken this year. This alteration will be in effect only for the period August 23, 1989 to June 1, 1990.

Approval of this permit alteration in no way implies a commitment by the Department of Commerce and Economic Development to provide funding for the project. Also, it is the responsibility of PWSAC to obtain all other necessary permits and authorizations from other agencies for the project.

If you have any questions regarding this matter, please contact Steve McGee or Jerry Madden of the Private Nonprofit Hatchery Program.

Sincerely,

Norman A. Cohen

Norman A. Cohen
Deputy Commissioner

Enclosure

cc: Jerry Madden
Steve McGee

11-K2LH

Alaska Department of Fish and Game

PRIVATE NONPROFIT SALMON HATCHERY

PERMIT NO. 20

NOTICE OF PERMIT ALTERATION

This notice, in conjunction with the original Private Nonprofit Hatchery Permit for Esther Lake Hatchery allows the Prince William Sound Aquaculture Corporation to increase production of pink salmon from 211 million to 261 million for the 1989 season only. This permit alteration will be in effect from August 23, 1989 to June 1, 1990. The increase in ~~production of pink salmon will be used to offset a reduction in chum salmon production~~ due to a lack of broodstock.

All other conditions of the permit remain as stated in the original permit, dated June 17, 1983, and its subsequent alterations.

Norman A. Cohen
Deputy Commissioner

8/28/89
Date

ATTACHMENT 9.

Alaska Department of Fish & Game

PRIVATE NONPROFIT SALMON HATCHERY PERMIT NO. 26

Permission is hereby granted to Prince William Sound Aquaculture Corporation, P. O. Box 1110, Cordova, Alaska 99574, hereinafter called the permittee, to operate a salmon hatchery facility located at Cannery Creek, 70 miles northwest of Cordova in Unakwik Inlet, 61° 01' 00" N. Latitude, 147° 30' 45" W. Longitude.

The hatchery shall be operated in accordance with (1) AS 16.10.400-480; (2) any regulations promulgated by the Department of Fish and Game or the Board of Fisheries (including those adopted after issuance of this permit); and (3) the Alaska Department of Fish and Game Statement of Policy on Permitting Nonprofit Salmon Hatcheries in Alaska, dated October 3, 1974.

Specific conditions which must be met in the operation of the salmon hatchery are described below and attached in Conditions 1 through 12 and in the Basic Management Plan that will be developed for Cannery Creek Hatchery.

If the permittee fails to comply with the terms of this permit within a reasonable period of time after notification of noncompliance, the permit will be suspended or revoked.

No more than 147,000,000 pink salmon eggs and 5,000,000 chum salmon eggs may be taken for incubation in any one year. Donor sources are listed below. Additional donor sources to be used will be approved through Fish Transport Permits issued by the department. Additions to or changes in approved sources and number of eggs which can be taken may be made by the department at any time.

SPECIES	SPECIES
Pink Salmon	Chum Salmon
(<u>Oncorhynchus gorbuscha</u>)	(<u>Oncorhynchus keta</u>)
Cannery Creek	Cannery Creek

The duration of this permit is unlimited unless the operation is found to be contrary to AS 16.10.400-480, or to any condition of this permit. That portion of this permit which describes the number of salmon eggs of any species that may be taken for incubation and the location from which the eggs are taken as well as any other condition of the permit will be subject to annual review and amendment by the department.

Don W. Collinsworth
Commissioner
Alaska Department of Fish and Game

6/22/88
Date

PERMIT CONDITIONS

1. The Annual Management Plan is a condition of the permit and must be followed and adhered to unless a request for a Notice of Permit Alteration or a change in the Annual Management Plan is approved by the Commissioner.

2. Between July 1, 1988 and February 15, 1989, the department and Prince William Sound Aquaculture Corporation shall jointly prepare a Basic Management Plan. Once approved by the Commissioner, it will be considered as a condition of the permit.

3. Salmon eggs procured by the hatchery must be from the department or a source approved by the department.

4. No salmon eggs or resulting fry may be placed in waters of the state other than those specifically designated in the permit.

5. No salmon eggs or resulting fry, sold to a permit holder by the state or by another party approved by the department, may be resold or otherwise transferred to another person.

6. No salmon may be released by the hatchery before department approval, and, for purposes of pathological examination and approval, the department shall be notified of the proposed release of salmon at least 45 days before the date of their proposed release by the hatchery.

7. Diseased salmon must be destroyed in the specific manner and place designated by the department.

8. Adult salmon may be harvested by hatchery operators only at specific locations as designated by the department.

9. Surplus eggs from salmon returning to the hatchery will be made available for sale first to the department and then, after inspection and approval by the department, to operators of other hatcheries authorized by permit to operate under §§ 400 - 480 of this chapter.

10. If surplus salmon eggs are sold by a permit holder to another permit holder, a copy of the sales transaction must be provided to the department.

11. A hatchery will be located in an area where a reasonable segregation from natural stocks occurs, but when feasible, in an area where returning hatchery fish will pass through salmon fisheries (§§ 2 ch 111 SLA 1974).

12. This permit is subject to annual review and amendment by June 30 of each year as prescribed by the department policy on hatcheries. Continuation of the permit is contingent

upon correction of any aspects of the hatchery operation that fail to meet the terms of the permit. If the operation of the hatchery is found not to be in the best interest of the public, the department may alter the conditions of the permit to mitigate the adverse effects. If the adverse effects are irreversible and cannot be sufficiently mitigated, termination of operations shall be initiated by the department. During the period of termination, which may not exceed four years, the permittee may harvest hatchery-produced salmon under terms of the permit, but may not release additional fish.

ATTACHMENT 10.

MEMORANDUM

State of Alaska

TO: John McMullen
Chief of Operations
FRED Division
Juneau

DATE: October 22, 1982

RECEIVED
OCT 28 1982
DIVISION OF F.R.E.D.

FILE NO:

TELEPHONE NO: 424-3214

FROM: Tim McDaniel TMcD
Area Biologist
FRED Division
Cordova

SUBJECT: Cannery Creek

As per your request, the following information outlines various operational aspects of the Cannery Creek hatchery which will significantly influence future salmon production at the facility. With the 1982 return of approximately 765,000 pink salmon, the brood-stock development program for that species is complete. After considerable discussion with Terry Ellison and other individuals involved with the general operation of the facility, it is my thinking that several decisions concerning production objectives need to be addressed. This memo attempts to serve two purposes: (1) answer the specific questions presented in your memo, and (2) provide some ground work for upcoming hatchery review meetings.

Chum Salmon Production Problems

Return timing of adult chum salmon from donor stocks used in the past (Eaglek River and Siwash Creek) is similar to the return timing of the Cannery Creek pink stock. Extensive interception of chum salmon brood-stock in terminal area pink salmon harvests will most likely occur as pink salmon production and subsequent adult returns continue to increase. P. W. S. A. C. has had little success in separating chum brood-stock from hatchery sales harvests of pink salmon at the Port San Juan hatchery. The use of an earlier returning chum salmon donor stock (i. e. Wells River) at Cannery Creek is not feasible because of the inability to control hatchery water temperatures to retard egg/alevin development.

Based on very limited returns of adult chum salmon to the facility ($\leq$200/year for the past three years), there appears to be a serious holding mortality problem due to high water temperatures and low dissolved oxygen levels. Terry Ellison has indicated that chum salmon holding mortality has reached 95 percent.

High hatchery water temperatures in August and September have also resulted in accelerated development of chum eggs/alevins with subsequent fry emergence in February and March. Extended freshwater rearing in raceways has been required with limited success of producing larger healthier fry for release in April when estuarine feeding conditions begin to improve. Hatchery water temperatures in February and March generally range from 33°F to 35°F. In summary, chum salmon production at Cannery Creek appears to be infeasible because: (1) chum salmon development rates are adversely affected by fall water temperatures in the hatchery, and (2) the simultaneous return of pink and chum salmon and excessive brood-stock holding mortality will severely restrict the brood-stock development program.

Pink Salmon Saltwater Rearing

As you know, the geography of the Cannery Creek estuary and the location of the hatchery building in relation to saltwater presents a difficult problem regarding transporting emergent pink salmon fry to a saltwater rearing facility. An option that has been discussed is the construction of a road from the burn pit to a small cove located on the north side of the Unakwik reef (Figure 1). Beaches in the vicinity of the cove have fairly steep gradients adequate for construction of a permanent dock and rearing facility. Access to the cove would require construction of approximately 3,700 feet of road. A temporary pipeline (i. e. 6 inch aluminum irrigation pipe) that could be installed each spring could be used to transport fry from the raceways to rearing pens.

The best reproduction of the cove and proposed road is from U. S. F. S. aerial photographs (Figure 2). Distances are approximations from 1:63,360 topographic maps. Naûtical charts do not provide accurate data concerning shoreline development in the cove, but we have the equipment to collect detailed depth profile data if required.

Cannery Creek Hatchery Potentials

1. Chum salmon production should be discontinued due to species incompatibility with the hatchery water supply.

2. Full production of pink salmon should be reached as soon as possible, which will require some major capitol investments as discussed below. Total pink salmon incubation capacity is calculated at 120 million eyed eggs based on a loading density of 300,000 eyed eggs/tray for LZ 40 incubators.

3. Saltwater rearing program should be started as soon as possible. The program should be developed to provide for two weeks of rearing for all emergent fry. The technology for this type of program has been developed at Port San Juan and studies conducted there suggest that a two weeks of intensive rearing will significantly increase marine survival.

Capitol Improvement Projects

1. Brood-stock enumeration and holding system. With the large return of pink salmon in 1982, it has become apparent that the present brood-stock holding system is inadequate to support proposed production goals.

Also, accurate enumeration of brood-stock is essential to orderly egg-take operations. A combination enumeration/holding system has been discussed and can be outlined at a later date.

2. Brood-stock collection/spawning system. The present system of collecting and spawning brood-stock (beach seining in the holding pond) is extremely labor intensive and inefficient. With the present system production will probably be restricted to less than 50 million eggs annually at best. Dave Gaither feels that a collection/spawning facility similar to the system at Hidden Falls will work quite well at Cannery Creek.

3. Lake outlet flow control system. The present method of controlling lake water level (spillway stop logs) is inadequate. With increased production control of the lake level will be essential particularly during mid winter periods when lake inflow is at a minimum. Mechanical flow control gates will be required to keep the lake level up to the top of the dam at all times for maximum water storage capacity.

4. Saltwater rearing facility. Previously discussed.

5. Storage building. Present storage space for supplies and equipment is inadequate. Equipment and supplies are presently being stored in the incubation room. All available floor space will be required for incubators when full production is reached.

6. Fry enumeration system. Increased production will require an improved fry enumeration system to monitor fry emergence and to segregate lots of emergent fry for the saltwater rearing program. Although the FCI digital fry counters are technically accurate for the purpose of enumerating fry, dewatering systems are required to make the counters mechanically functional. At full production one dewatering/counter assembly will be required for each raceway (8).

<u>Summary</u>

Although the raceways at Cannery Creek were designed primarily for rearing of emergent chum fry, the raceways will be essential as a fry collection system if the saltwater rearing program is initiated. The maps I have included to describe the proposed road and cove location do not provide much detail. Perhaps George has access to more detailed maps and could provide better data and some basic cost estimates for road construction.

I have outlined some basic ideas for moving the Cannery Creek facility toward full production. Hopefully, these ideas will generate some discussion and get the team wheels moving to formulate a comprehensive capitol improvement package that will enable the facility to reach full capacity as soon as possible. This facility has been operating for three years, the hatchery has been debugged, and the brood-stock is available. I think it is time that Port San Juan and Kitoi have some competition! I'm hoping that the C. I. P. team for Cannery Creek will evaluate some or all of the ideas I have listed and develop specific recommendations for presentation at the facility review meeting in February.

cc: Daisy
Krasnowski
Kaill
Cunningham
Gaither
Ellison
Miller
Kohler

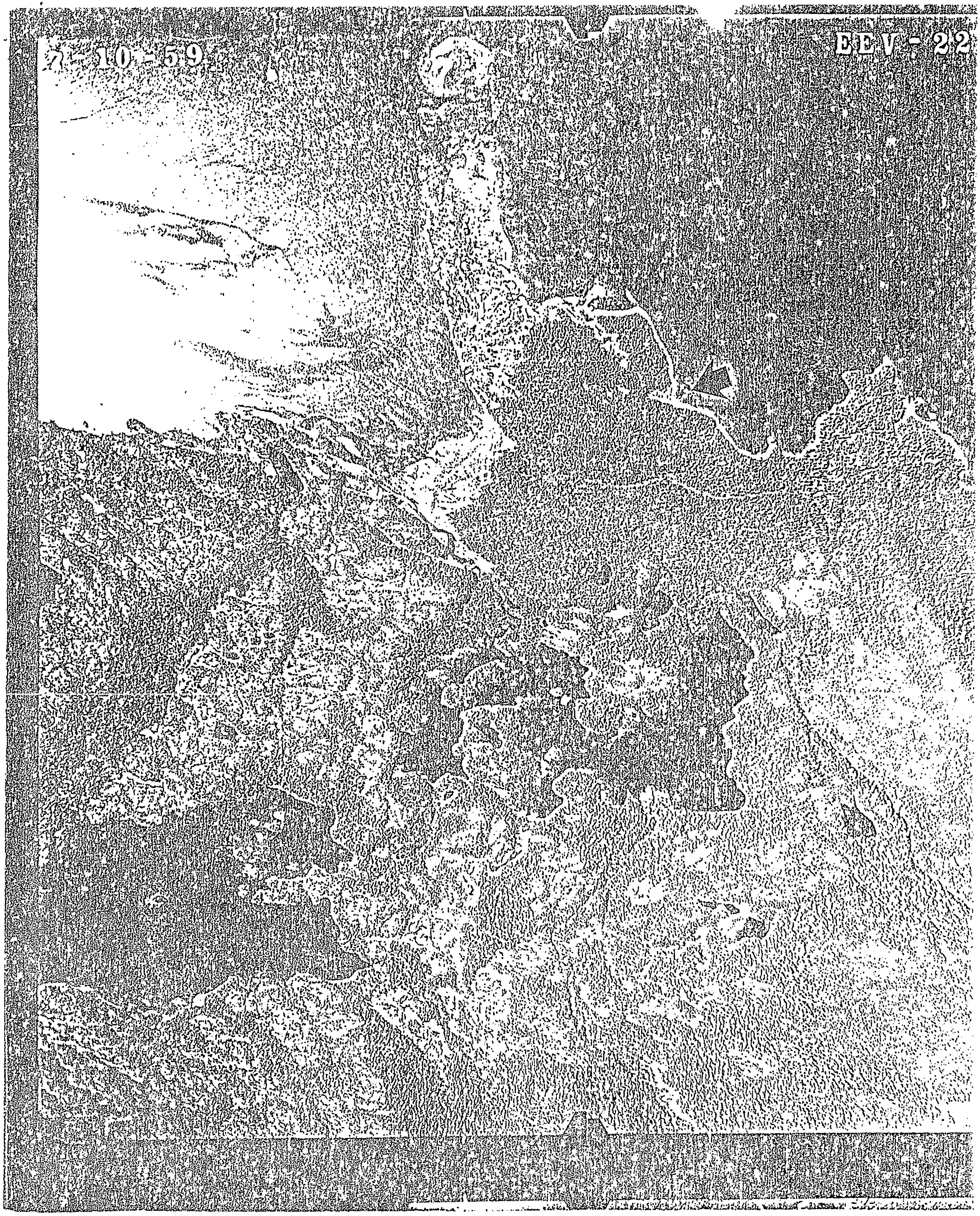


Figure 1. Reproduction of U. S. F. S. aerial photograph of Cannery Creek area showing proposed saltwater rearing location.

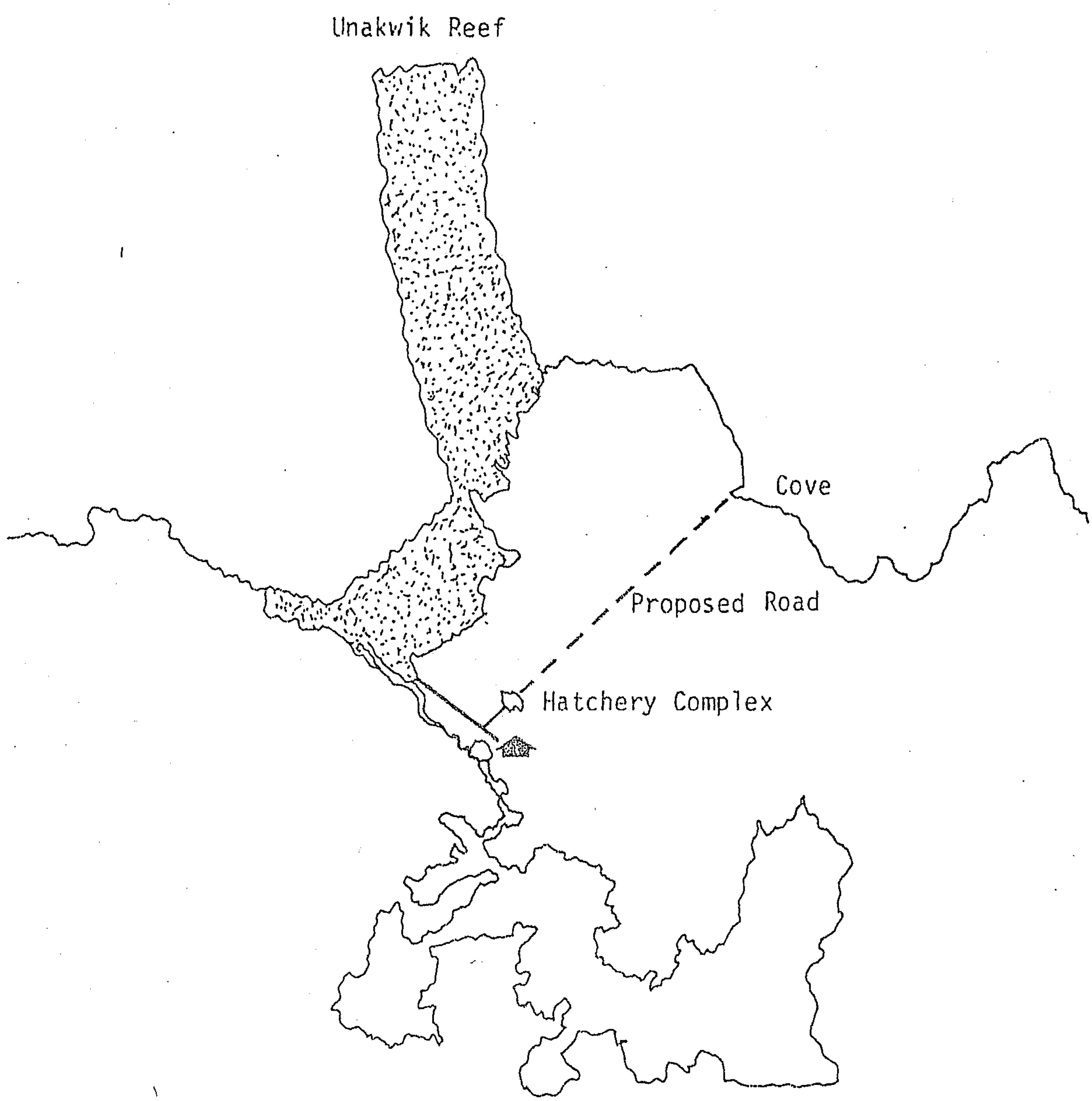


Figure 2. Cannery Creek Hatchery and proposed road from burn pit to cove.

Attachment 11.

Excerpt from 2010 AFK Annual Management Plan

'... 3.5 Special Management Strategies

Pink Salmon: Because there is no way of isolating hatchery fish from wild stocks in the general waters of the Southwestern, Montague, and adjacent districts, these districts can only be opened and closed as the wild stock run strength will allow. When the hatchery return can withstand a higher exploitation rate than the returning wild stocks, hatchery fish that are not intercepted in the mixed stock areas of the general districts continue into the Port San Juan Subdistrict and the waters of Sawmill Bay. The Port San Juan Subdistrict was established in order to harvest the highest concentration of surplus hatchery fish in a mixed stock fishery when wild stock interception must be minimized.

The principal tool available to manage the hatchery's return is emergency order manipulations of fishing time in the four designated approach zones to the hatchery: the Point Elrington Subdistrict, the Port San Juan Subdistrict, the THA in outer Sawmill Bay, and the SHA in inner Sawmill Bay (Figure 3). The approaches to AFK Hatchery will be conservatively managed to provide for PWSAC's sales harvesting needs. Test fishing and CPF openings in the general waters of the Southwestern District will occur, as necessary, to assess the timing and magnitude of the late pink salmon return. When it is necessary to protect wild stocks and/or to decrease interception of hatchery fish to ensure corporate escapement objectives are met, a closure of the two subdistricts during the regular season may be used. Fishing time will be extended in the Port San Juan Subdistrict when there is surplus hatchery production and wild stocks do not need protection to meet minimum escapement requirements. When it is apparent that a large hatchery surplus exists, every effort will be made to extend fishing time in waters of the Port San Juan Subdistrict in such a manner as to prevent a large buildup of fish from occurring and to allow for a timely harvest of the best possible quality fish while protecting wild stock escapements.

Performance of the hatchery return is evaluated by comparison of daily harvest rates to a predicted run entry table (Table 3). In addition, sex ratios in the hatchery harvest predict the mid-point of the return. PWSAC will provide these two types of data from the cost recovery harvest to ADF&G management staff on a daily basis during the season so the area management biologist can make estimates of the number of salmon left in the run. If corporate escapement problems occur at the hatchery, or western PWS wild stocks are not meeting escapement goals, subdistrict closures may be made based upon the magnitude of the shortfall and the stage of the run. Protection would be provided by the closure of the Port San Juan and Point Elrington Subdistricts. These areas will be reopened as hatchery returns recover and wild stock escapements allow. Should surplus fish build up in front of the hatchery in excess of PWSAC's harvesting abilities, the commercial fleet may be brought in for a special opening of the SHA.

The effective management of mixed stock fisheries is difficult. It is the intent of the ADF&G to provide for the stated PWSAC corporate escapement goals by species. Achieving the target revenue goal will depend on the timing and magnitude of the PWSAC pink salmon return, the average fish size, and the price per pound PWSAC receives. It will also depend upon precise inseason assessment of both wild and hatchery run strengths. Depending upon the precision of inseason run assessment, the actual percentages of PWSAC total returns by species which provide corporate escapement may fall above or below the stated goals. If precise and timely stock identification data are available, the ADF&G will use them to manage the fisheries inseason for an allocation of PWSAC produced pink, chum, and sockeye salmon between the common property fishery and PWSAC. Pink salmon will be managed for PWSAC corporate escapement after July 20. Sockeye and chum salmon will be managed for PWSAC corporate escapement by stock ... '

Excerpt from the 2010 WNH Annual Management Plan

'... <u>3.5 Special Management Strategies</u>

Pink Salmon: Because there is no way of isolating hatchery fish from wild stocks in the waters of the general purse seine districts, these districts can only be opened and closed as the wild stock run strength will allow. When the hatchery return can withstand a higher exploitation rate than the returning wild stocks, hatchery fish that are not intercepted in the mixed stock areas of the general districts continue into the Esther Subdistrict and the waters of Lake and Quillian Bays. Wild stock pink salmon escapement shortfalls have occurred several times in the Coghill District since 1988. Beginning in 1994, CPF openings in the Esther Subdistrict have been restricted to within one and a half miles of Esther Island to minimize the harvest of weak pink salmon stocks destined for Port Wells. Recommendations discussed by the Salmon Harvest Task Force have included closing those waters west of Lake Bay to seine harvests during weak wild stock returns to provide a greater corridor for wild fish transiting the Esther Subdistrict.

The principal tool available to manage the hatchery pink salmon return is emergency order manipulation of the Esther and Perry Island Subdistricts (Figure 1). Closure of the subdistricts during the regular season can be used to decrease interception of hatchery fish to assure that the corporation can achieve its cost recovery and broodstock objectives. When it is apparent that a large hatchery surplus exists in the Esther or Perry Island Subdistricts, every effort will be made to provide fishing time in these areas in such a manner to prevent a large buildup of fish from occurring and to allow for a timely harvest of the highest quality fish possible.

Performance of the hatchery return is evaluated by comparison of daily harvest rates to a predicted run entry table. In addition, daily sex ratios in the hatchery harvest predict by a regression equation the fraction of the run that has returned to date. PWSAC will provide these two types of data from the cost recovery harvest to ADF&G management staff on a daily basis during the season so the area management biologist can make estimates of the number of salmon remaining in the run. If corporate escapement problems occur at the hatchery, CPF fishery restrictions will be made in the Esther and/or Perry Island Subdistricts based upon the magnitude of the shortfall and the stage of the run. If fish surplus to desired hatchery escapement accumulate in front of the hatchery, the commercial fleet may be brought in for a special opening of the THA and/or SHA …'

Excerpt from the 2010 CCH Annual Management Plan

'… <u>3.5 Special Management Strategies</u>

The CCH is located in Unakwik Inlet in the Northern District. Returning hatchery pink salmon will influence management of the traditional fisheries particularly in the Northern District. Present management strategies for the remaining seine districts are based on escapement observations of wild stocks of pink and chum salmon throughout the Sound. Poor wild stock escapement will require closures or reduced fishing time in the remaining districts, which in turn may shift the harvest of hatchery returns to the terminal areas of Unakwik Inlet (including the CCH THA and SHA).

A strong wild stock return on the other hand, could result in a heavy interception of the hatchery return in the other fishing districts and result in an insufficient return to meet broodstock and cost recovery goals. Selected closures of the waters of Unakwik Inlet may be necessary to permit sufficient escapement to meet cost recovery and broodstock needs. The principal tool available to manage the hatchery fishery is emergency order manipulation.

Fishing in the SHA and THA is expected to be limited to cost recovery operations from the start of the pink salmon return in the Northern District, and is expected to remain so throughout the completion of the cost recovery harvest. However, if significant numbers of fish build up in excess of corporate needs, these areas or portions of them could be opened to the commercial fleet. If the hatchery return requires additional protection to meet broodstock or cost recovery goals, the Cannery Creek Subdistrict may be closed. During periods when the Cannery Creek Subdistrict closure is in effect to provide protection to cost recovery fish, the ADF&G may allow the hatchery operator to harvest fish in Unakwik Inlet outside the SHA boundaries (Figure 1) to maintain fish quality. This will occur only if the escapement of local wild stocks is adequate. When Unakwik Inlet is open to the common property fishery, the special harvest area will not be expanded.

Performance of the hatchery return is evaluated by comparison of the daily harvest to the predicted run entry (Table 1). In addition, daily sex ratios in the hatchery harvest predict by a regression equation what percentage of the total run has accumulated to date. PWSAC will provide these two types of data from the cost recovery harvest to ADF&G management staff on a daily basis during the season so the area management biologist can make estimates of the number of salmon left in the fish run. If corporate escapement problems occur at the hatchery, subdistrict closures will be made based upon the magnitude of the shortfall and the stage of the run.

The effective management of mixed stock fisheries is difficult. It is the intent of the ADF&G to provide the stated PWSAC corporate escapement goals by species. Achieving the target revenue goal will depend upon the timing and magnitude of the PWSAC salmon returns, the average size and price per pound PWSAC receives. It will also depend upon precise inseason assessment of both wild and hatchery run strengths. Depending upon the precision of inseason run assessment, the actual percentages of PWSAC total returns by species which provide corporate escapement may fall above or below the stated goals. If precise and timely stock identification data are available, the ADF&G will use them to manage the fisheries inseason for an allocation of PWSAC produced pink, chum, and sockeye salmon between the common property fishery and PWSAC. Pink salmon will be managed for PWSAC corporate escapement after July 20. Sockeye and chum salmon will be managed for PWSAC corporate escapement by stock.

ATTACHMENT 12. ADF&G AMR PWS/CR 2007.

Appendix D5.–Pink salmon escapement indices by district, 1971-2007.

Year	Eastern	Northern	Coghill	Northwestern	Eshamy	Southwestern	Montague	Southeastern	Total
					Escapement Indicies				
1965	257,853	59,820	91,584	159,011	9,340	65,380	77,042	255,926	975,956
1966	544,980	288,710	135,440	79,960	11,720	115,570	42,220	204,570	1,423,170
1967	255,240	144,200	65,240	82,980	5,020	42,950	10,020	236,610	842,260
1968	364,930	151,120	108,020	117,430	10,770	172,770	52,350	179,120	1,156,510
1969	160,600	94,770	39,020	23,830	0	57,890	1,550	26,910	404,570
1970	387,090	125,360	95,170	82,660	7,610	66,790	73,880	140,660	979,220
1971	352,800	126,210	62,160	14,320	1,710	79,140	296,730	179,480	1,112,550
1972	344,470	83,900	30,960	39,020	1,100	29,530	33,140	79,060	641,180
1973	309,040	69,660	493,780	2,910	0	52,320	119,520	177,780	1,225,010
1974	256,880	206,750	56,940	163,930	6,240	160,980	11,750	94,650	958,120
1975	412,560	38,260	452,430	4,990	0	77,270	85,380	194,670	1,265,560
1976	402,792	106,248	53,908	41,886	0	32,639	7,852	66,953	712,278
1977	409,082	47,897	320,680	72,591	0	179,682	185,174	302,561	1,517,667
1978	298,037	88,816	67,084	65,514	0	110,363	30,761	94,811	755,386
1979	755,752	271,952	125,544	155,077	0	286,489	308,412	998,751	2,901,977
1980	300,871	105,551	148,066	85,663	0	81,095	100,985	272,811	1,095,042
1981	650,401	206,282	140,436	108,158	0	137,759	488,066	435,217	2,166,319
1982	508,204	198,838	309,202	121,085	0	134,827	114,421	462,541	1,849,118
1983	450,165	138,993	284,164	171,938	0	145,779	217,597	594,470	2,003,106
1984	1,143,775	439,886	365,226	412,278	0	304,859	169,612	734,202	3,569,838
1985	720,386	166,768	238,728	181,797	0	152,429	316,483	571,406	2,347,997
1986	384,382	131,956	109,798	78,027	3,513	69,388	45,492	163,378	985,934
1987	517,221	114,522	67,761	67,809	3,450	129,192	144,085	328,177	1,372,217
1988	394,111	140,981	42,985	69,627	0	118,359	67,928	137,173	971,164
1989	357,249	95,445	48,802	72,591	18,578	168,518	164,540	307,953	1,233,676
1990	428,723	110,638	45,558	94,359	17,274	136,721	106,603	296,029	1,235,905
1991	427,069	159,909	84,790	89,437	19,152	176,887	239,782	528,766	1,725,792

-continued-

Appendix D5.–Page 2 of 2.

Year	Eastern	Northern	Coghill	Northwestern	Eshamy	Southwestern	Montague	Southeastern	Total
	Escapement Indicies								
1992	194,962	72,323	23,122	42,805	2,716	64,652	47,029	94,928	542,537
1993	314,727	95,602	41,666	45,847	9,348	98,573	144,784	315,093	1,065,640
1994	613,866	178,151	65,648	141,290	11,799	143,479	58,820	196,228	1,409,281
1995	396,696	84,447	46,029	50,582	10,182	82,490	183,448	336,310	1,190,184
1996	584,236	218,022	104,781	86,709	3,000	63,337	92,966	330,285	1,483,336
1997	345,725	65,260	52,961	53,740	914	112,010	206,943	585,135	1,422,688
1998	377,700	213,288	85,968	97,485	4,644	280,335	161,275	199,410	1,420,105
1999	622,502	214,723	168,816	52,340	6,900	163,347	381,054	853,180	2,462,862
2000	554,984	168,247	223,646	66,078	4,286	131,648	227,881	282,258	1,659,028
2001	436,585	163,573	148,665	102,294	2,963	176,503	314,323	655,480	2,000,386
2002	226,068	138,204	54,882	50,981	1,397	35,554	71,461	364,630	943,177
2003	957,327	262,502	375,147	103,931	5,206	130,356	320,494	691,769	2,846,732
2004	724,663	163,858	79,010	51,306	2,300	108,192	183,891	687,903	2,001,123
2005	1,025,756	579,079	528,264	401,640	32,396	272,572	566,002	1,330,407	4,736,116
2006	248,592	211,603	145,511	127,836	11,247	118,205	149,798	178,009	1,190,802
2007	374,723	158,345	197,405	68,667	9,461	116,130	142,769	443,914	1,511,416
	Even Cycle Average (1966-2006)								
	442,110	168,688	111,949	100,759	4,744	118,062	88,101	250,458	1,284,869
	Odd Cycle Average (1971-2005)								
	486,227	158,718	187,856	96,482	5,793	131,114	219,260	470,179	1,742,342

Note: Historical data revised in 1989. Coghill and Northwestern escapement numbers correspond to current district boundaries. Northern District column includes both Northern and Unakwik district counts combined.

ATTACHMENT 13.

PWSAC Historic Production Summary

Species	Pink

Sum of Total Return	Hatchery			
Return Year	AFK	CCH	WNH	Grand Total
2002	7,759,064	1,588,603	5,617,122	14,964,789
2003	7,065,581	8,288,949	17,847,316	33,201,846
2004	5,230,138	2,761,241	2,704,727	10,696,106
2005	10,117,138	13,491,670	9,164,154	32,772,962
2006	5,210,424	2,915,048	4,065,035	12,190,507
2007	15,755,182	7,430,043	7,540,222	30,725,447
2008	6,112,588	10,992,852	8,737,521	25,842,961
2009	10,696,538	3,309,839	3,237,364	17,243,741

2002-2009 Average 22,204,795

ATTACHMENT 14.

Science, Scientists, and Policy Advocacy

ROBERT T. LACKEY

National Health and Environmental Effects Research Laboratory, U.S. Environmental Protection Agency, Corvallis, OR 97333, U.S.A., email lackey.robert@epa.gov

Introduction

I am concerned that we scientists in conservation biology, ecology, natural resources, environmental science, and similar disciplines are collectively slipping into a morass that risks marginalizing the contribution of science to public policy. Advocating personal positions on ecological policy issues has become widely tolerated as acceptable professional behavior and is even encouraged by a substantial fraction of the scientific community (Marris 2006; Scott et al. 2007). Scientists are uniquely qualified to participate in public policy deliberations and they should, but advocating for their policy preferences is not appropriate.

Despite an extensive debate in the literature on the proper role of science and scientists in policy deliberations, points of general agreement and specific differences often get lost amid the semantic confusion caused by inconsistent definitions for key words or concepts (Trudgill 2001). Table 1 provides the precise definitions I have used throughout this essay.

Those of us who provide scientific information to decision makers and the public should strive to be more vigilant, precise, demanding, and rigorous in distinguishing between policy-neutral and policy-inculcated scientific information. Science is only one element of the complex deliberations over major ecological policy questions that take place in a democracy, but science is critical, and scientists can and do play an important role (Sarewitz 2004; Lackey 2006).

My unequivocal overall view on the role of scientists in ecological policy and management is, first, that scientists should contribute to the policy process. This is not only the right thing to do, but we are also obligated to do so, especially if our work is funded by public resources. I do not hold with the notion that it is sufficient for scientists to publish their findings solely as scholarly papers. The assertion that scientists should be involved in providing and explaining the underlying science to help resolve important policy questions is, for me, a given.

Second, when scientists contribute to policy analysis and implementation, they must exercise great care to play an appropriate and clearly defined role. The interface between science and policy can be bewildering for many of us who develop, provide, or interpret scientific information. Working at the interface is also where many of us mislead or confuse decision makers and the public because we let our personal policy preferences color our science.

The formidable challenge of developing and providing technical and scientific information to inform policy deliberations in an objective and relevant way is not unique to ecological fields (Rykiel 2001). Whether one is working as a stock analyst in the research unit of a brokerage firm (Boni & Womack 2003), a medical expert testifying in malpractice trials (Caldwell 2005), a funding officer at an international development agency that might finance a proposed shrimp-farming operation (Béné 2005), or an intelligence analyst within a government national security agency (Armstrong 2002), the job of providing accurate, relevant, and policy-neutral information is always a challenge.

Policy Context

Most of today's ecological policy issues are politically contentious, socially wrenching, and replete with scientific uncertainty (Pielke 2004; Robinson 2006). Examples include reversing the decline of salmon in western North America; deciding on the proper role of logging on public lands; ameliorating the effects of human-caused climate change; avoiding the extinction of species; and making sense of the confusing policy choices surrounding notions of sustainability.

Paper submitted August 16, 2006; revised manuscript accepted September 28, 2006.

Conservation Biology Volume 21, No. 1, 12-17

DOI: 10.1111/j.1523-1739.2006.00639.x

Table 1. Definitions of keywords used in this essay.

Normative science: science developed, presented, or interpreted based on an assumed, usually unstated, preference for a particular policy or class of policy choices.
Policy: a decision or plan of action for accomplishing a desired outcome.
Policy analysis: formal assessment of the consequences and implications of the possible options for addressing a policy problem.
Policy advocacy: active, covert, or inadvertent support of a particular policy or class of policies.
Politics: process of debate, negotiation, and compromise for achieving a desired policy goal.
Preference: the preferred option from among a set of policy choices or alternatives.
Science: information gathered in a rational, systematic, testable, and reproducible manner.
Scientist: a person who generates or interprets scientific information or science.
Value: a core belief that tends to determine or shape personal or group policy preferences.

Ecological policy issues are inherently complex and are often described by political scientists as being "wicked" and "messy" (Salwasser 2004). All these issues share several qualities: (1) complexity (they have multiple options and trade-offs); (2) polarization (clashes between competing values are routine); (3) winners and losers (for each policy choice, some interests will clearly benefit, some will be harmed, and the consequences for others are uncertain); (4) delayed consequences (the policy options often provide no immediate "fix" and the benefits, if any, of painful concessions may not be evident for decades); (5) decision distortion (advocates often appeal to strongly held values and distort or hide the real policy choices and their consequences); (6) national versus regional conflict (national priorities often differ substantially from those at the local or regional level); and (7) misuse of scientific information (science can end up an inappropriate battleground because arguments over science are often actually a surrogate venue for arguments over values and preferences) (Lackey 2006). As if ecological policy issues were not muddled enough, they often become further clouded by skepticism about the motivation of scientists and the accuracy of the scientific information they provide (Mills 2000; Pielke 2004). Most science is funded by government agencies, businesses and corporations, and myriad public and private interest and advocacy groups (Sarewitz 2004). Each arguably has a vested interest in the outcome of the debate and often promulgates "science" that appears to support its favored position (Doremus 2005).

Science and Scientists

What is the appropriate role for scientists in policy making? Our role is not described adequately under the current and simplistic rubric of providing the best available science or good science (Doremus & Tarlock 2005; Sullivan et al. 2006). Furthermore, scientists are often asked to contribute scientific information in the midst of clashing values, differing preferences, and opposing, often mutually exclusive, societal priorities (Lach et al. 2003; Pielke 2004). The public and bureaucratic discourse surrounding wicked, messy ecological policy issues is not for the psychologically sensitive, those with thin skins, or anyone with an aversion to being challenged scientifically or professionally (Lackey 2006). Regardless of the reasons, many scientists are reluctant to contribute beyond publishing their scientific contributions in scholarly journals (Lach et al. 2003).

One common concern about the science-policy interface is that some so-called science is imbued with policy preferences (Trudgill 2001). Such science is labeled as normative and its use is potentially an insidious kind of scientific corruption (Lackey 2004). What separates normative science from "regular" science is that normative science is developed, presented, or interpreted based on a tacit, usually unstated, preference for a particular policy or class of policy choices. Normative science often is not perceptibly normative to policy makers or even to many scientists. The use of such science by scientists, however, is stealth policy advocacy even if its use is not intentional. As is argued by postmodernists, because all science is socially constructed, science is value driven and is, therefore, normative. My discomfort, however, is not with the notion that science is a human enterprise and therefore reflects the values of the participants, but with science influenced by policy preferences.

Attempting to be both the provider of policy-neutral science and an advocate for one's personal policy preferences is laden with conflicts of interest and, if not carefully communicated, is potentially unethical (Mills 2000). The same types of conflicts are present when one organizational unit attempts to serve as both the provider of science and the regulator or manager of environmental or natural resource (Sullivan et al. 2006). In government bureaucracies it is an old and ongoing challenge to keep the research and/or science enterprise independent and policy neutral rather than manipulating it to help sell or defend the agency's policy decisions (Cohn 2005; Doremus 2005).

Many writers who muse over the proper role of science in ecological policy concentrate on the philosophical notion of positivism and the fact-value distinction (Roebuck & Phifer 1999). I subscribe to the view that science is not free of values. It is, after all, a human enterprise, but this fact does not make all science normative (Odenbaugh

2003). Policy-neutral science strives to describe the world accurately and is characterized by transparency, reproducibility, and independence.

Using the terminology of philosophy, but without becoming mired in the nuances of philosophical analysis, consider the simple but fundamental difference between *is* (i.e., fact) and *ought* (i.e., preference) statements. Science deals with the "is" world (facts about the past, present, or future). For example, consider the distribution of a hypothetical bird found only in a limited geographic area and with an overall population level that appears to be declining at 5% per year. Such an observation (the decline) is a scientific "is" statement. Whether this fact documenting the population decline is something that warrants a change in policy would be an "ought" statement—a policy question. The policy world deals legitimately and appropriately with the oughts and shoulds (i.e., preferences): Should the decline of the bird population be reversed? Science is restrained to statements of is: The population is declining at 5% per year.

A current example that vividly illustrates the is/ought dichotomy is the case of declining salmon populations in the Pacific Northwest (U.S.A.). Many dams have a measurable effect on these populations. One oft-debated policy option to help restore salmon runs is to remove or breach dams. It is common for scientists to be asked to gauge the likely effects of removing, or preserving, a particular dam or set of dams—a legitimate and appropriate role for scientists. There is, however, no scientific imperative to remove, or maintain, any dam for any ecological reason, including salmon recovery. All of the policy options would have ecological consequences, some of which may even be catastrophic from a salmon perspective, but ecological consequences are simply one element that the public and decision makers must weigh in choosing from a set of options. Understanding the likely ecological outcomes of each choice is what the public and decision makers need from scientists as they weigh policy alternatives. They do not need personal opinions from scientists on which policy option ought to be chosen.

How should scientists explain to the public and decision makers the relevant scientific information pertaining to the likely effects of dam construction or removal? There are obviously many ecological changes that will take place when a dam is removed but what words should be used to describe those changes? What point of ecological reference should be used, if any? Should benchmarks of any kind be used?

Often I hear or read in scientific discourse words such as *degradation, improvement, good,* and *poor*. Such value-laden words should not be used to convey scientific information because they imply a preferred ecological state, a desired condition, a benchmark, or a preferred class of policy options. Doing so is not science, it is policy advocacy. Subtle, perhaps unintentional, but it is still policy advocacy. An argument is sometimes made that such terms as *degradation*, *good*, and *healthy* can be used in scientific reports if the terms are clearly defined, measured, and monitored. Why use them unless you are conveying the impression that one particular condition is preferred policy wise? A forest that has been clearcut is *degraded* habitat from the perspective of Spotted Owls and red tree voles, but it is *improved* habitat from the perspective of other species such as White-crowned Sparrows and black-tailed deer. The science is exactly the same, only the policy context differs. The appropriate science words are, for example, *change, increase,* or *decrease*. These words describe the scientific information in ways that are usually considered policy neutral. In short they convey no policy preference and convey science in a policy-neutral manner. Be clear, be candid, be brutally frank, but be policy neutral when providing science to the public, policy makers, and others.

Scientists have a responsibility to correct misinterpretations of science, especially if it is being conveyed in ways that imply support for particular policies. Even though scientific information alone does not carry a policy imperative, making sure that policy *advocates* and policy *makers* understand and use scientific information accurately and honestly is essential (Doremus & Tarlock 2005). Some scientists believe that not speaking up when science is being misinterpreted or misused in policy deliberations is tantamount to dereliction of duty (Karr 2006). Conversely, scientists have an obligation to avoid conveying overtly or covertly *any* policy preference. Using normative science is a case of covertly advocating a policy preference. Among some conservation biologists, ecologists, and those from similar professional disciplines, the implicit policy preference is assumed to be that ecosystems unaltered by humans are inherently good, or at least preferable to ecosystems altered by humans (van Houtan 2006). Unstated, but implied, is that the less altered an ecosystem the better. But science leads to no preferred state or to any inherently good condition. In short, there is no scientific imperative for adopting any policy option (McCoy & Atwood 2005).

There is no universally accepted list of implicit policy preferences that is typically imbedded within normative science in ecological and environmental disciples. The following policy preferences are common: human-caused extinctions are inherently bad and should be avoided; unaltered ecosystems are preferable to altered; reducing complexity in ecosystems is undesirable; natural evolution is good, human intervention is not; more biological diversity is preferable to less biodiversity; and native or indigenous species are preferable to non-native species. These examples (and their converses) are each valid policy preferences, but not one is a scientific imperative (Matsuda 1997).

How widespread is normative science in disciplines such as conservation biology, ecology, fisheries, wildlife, and forestry? In my experience with a number of different ecological policy issues, normative science is frequent. I often observe biological diversity or ecological integrity calculated solely on the number of native species. Except for someone doing truly basic, independent, or nonapplied research, the decision to include, or exclude, exotic or non-native species in biodiversity calculations is a policy choice and not a choice for scientists to make. That is not to say the native species and exotic species are interchangeable; they are not, but neither native species nor exotic species are inherently preferable in a scientific sense.

Some scientific societies and other professional organizations assert that biological diversity is inherently good. Understanding the role of biological diversity may be important to explaining ecosystem structure and function and even essential for sorting out evolutionary processes, but a value judgment must be invoked to define certain levels of biological diversity as inherently good or that increasing biodiversity is preferable, policy wise, to decreasing biodiversity (Meine et al. 2006). Such a value judgment reflects a specific policy preference, but there are competing policy preferences that are also valid. Furthermore, how should those scientific and professional societies that promulgate explicit ecological policy preferences promote those preferences? Should their journals only publish papers that accept their policy preferences? Should the society accept advertising that does not explicitly support their stated policy positions? Is it realistic to expect outsiders to accept science published in their journals as being policy neutral? Once policy preferences are rooted in the core of the scientific enterprise, it is not clear to me how scientific independence and credibility can survive over the long term.

Another example of the inappropriate blending of science and policy preference is the application of the metaphor of ecosystem health—a common, even pervasive, use of normative science (Lackey 2003). To most proponents of ecosystem health, the alluring feature of the human health metaphor is that people have an inherent understanding of personal health. We each have an idea of what constitutes a healthy person in contrast to a sick person. By extension most people envision instinctively a healthy ecosystem as being pristine or at least appearing to be minimally altered by human action (e.g., a primordial forest, a wilderness lake, or perhaps a pastoral landscape). Thus, it is often argued that ecosystem health is intuitively grasped by the general public, policy officials, and scientists.

Applying the notion of human health to ecosystems provides a simple paradigm for viewing ecological policy questions. By implication, adopting the metaphor also defines what type of information (i.e., scientific) is necessary to help decision makers (Lackey 2003). When I am sick, I seek the technical expertise of a medical practitioner. Therefore, applying the same metaphor, when an ecosystem is sick it follows that an ecosystem health professional ought to be consulted. Ecosystem health is a value-driven policy construct. Yet often it is passed off as science to unsuspecting policy makers and the public.

Who decides what is the preferred state of an ecosystem? Arguably there is a consensus that a healthy human is preferable to a sick one, but what is the analog for ecosystems? Sometimes and in acknowledgment of the intellectual weakness of the notion of ecosystem health, scientists assume a preferred state but hide behind a cloak of scholarly precision with statements such as "We used a precise definition of ecosystem health to analyze the ecosystem, but others misused or misinterpreted the results." and "We cannot be responsible for how others use the results." True, but why use the metaphor if people are likely to misuse the scientific information?

Think what the average recipient of scientific information actually hears when data or assessments are packaged or presented under the rubric of ecosystem health. As with humans, healthy is good. The opposite condition must be unhealthy, which is surely undesirable in ecosystems as it is in humans. Is this a fair way to describe policy alternatives? One person's damaged ecosystem is another person's improved ecosystem. A healthy ecosystem can be either a malaria-infested swamp or the same land converted to an intensively managed rice paddy. Neither condition can be seen as healthy except through the lens of an individual's values and policy preferences (Freyfogle & Newton 2002).

Should a healthy ecosystem be defined as the ecological state that existed a 1000 years ago, just prior to 1492, or at the end of last week? The answer is a value judgment, a policy choice, perhaps the product of political deliberations, but it is not solely a scientific decision (Hunter 1996). Scientists can and should assess the ecological consequences of adopting each possible policy or management goal (i.e., various alternative definitions of "healthy" ecosystem), but the choice of which state of the ecosystem is the desired goal is a societal one (Rykiel 2001).

Politically, from what I observe, the use of normative science cuts across the ideological spectrum. It seems no less common coming from the political Left or Right, from the Greens or the Libertarians. Regardless of the virtue of the policy preference, normative science is a corruption of science.

Fair or not, it is true that some scientists, at least as perceived by many people, appear to operate as policy advocates, not as unimpeachable providers of policy-neutral information. They are observed, for example, publicly arguing for, or against, the Kyoto Protocol, the Convention on Biological Diversity, legislation to protect marine resources, or a controversial housing development. In my own area of research, for example, many scientists sign petitions to remove, or preserve, a particular salmon-killing dam for reasons that sound like science, read like science, are presented by people who cloak themselves in the accouterments of science but who are actually offering nothing but policy advocacy masquerading as science.

Conclusion

We must achieve within ecological and natural resource professions a clear understanding of the distinctions between science and policy and an understanding of the appropriate roles and responsibilities of science, scientists, and policy advocacy. So, what specifically should a vigilant scientist do to assure that the proper roles of science, scientists, and policy makers are understood and followed? First, be sensitive to the boundary between scientific or technical issues and value judgments. The boundary between policy neutrality and policy advocacy may not always be a bright line, but be especially vigilant when the line becomes dim.

Second, when the major points of dissention in a policy debate are over values and preferences (the usual case), try to exhort decision makers to focus on these often fractious elements of the decision making process rather than the technical and scientific aspects. Debates of questions of science often end up serving as a surrogate polemic for the inability (or unwillingness) of decision makers to adjudicate unpleasant value and preference trade-offs. Do not fall into the trap of substituting debate over scientific information and interpretation of data for debate over which values and preferences will carry the day.

Third, be brutally honest with decision makers about the technical feasibility of each possible policy option and the uncertainties associated with the resulting ecological consequences. Often, the most useful input scientists can provide is to identify the estimated probability of success (for achieving the stated policy goal) for each of the various competing policy options.

Many of today's ecological policy issues are contentious, socially divisive, and full of conundrums. They are, however, typical of those that professional ecologists will confront for the foreseeable future. Those of us who provide information to help inform the participants involved in ecological policy debates must be cognizant of and appreciate the importance of scientific information, but in a democracy we also must recognize the reality that scientific information is just one element in complex political deliberations.

To policy makers, I say be alert. Call our hand when you observe us overstepping our role as scientists and slipping into stealth policy advocacy. Scientific information is too important to the resolution of vital, divisive, and controversial ecological issues to allow some scientists to marginalize science through its misuse. Do not allow the overzealous among us to corrupt the entire science enterprise.

To scientists, I say get involved, but play the appropriate role. If you choose to advocate your personal policy preferences, make it clear to everyone involved that you have stepped out of a scientific role and into the role of policy advocate. In playing the role of policy advocate, be aware that your values and preferences inherently are no more (or less) important than other participants in the policy debate. To do otherwise is to corrupt both the political process and scientific enterprise.

Acknowledgments

Over my career in government, academia, and the private sector, many colleagues helped shape my current views about the proper role of science and scientists in ecological policy. Several colleagues reviewed versions of this essay. Particularly helpful were the suggestions provided by K. I. Ashley, M. Bagdovitz, L. L. Bailey, S. M. Bartell, G. A. Bisbal, G. W. Boehlert, R. D. Cardwell, T. H. DeWitt, S. L. Duncan, J. M. Emlen, A. K. Fitzsimmons, E. T. Freyfogle, S. J. Grabowski, M. Healey, G. M. Hidy, M. L. Hunter, J. Hurley, G. Ice, S. J. Jordan, P. L. Kennedy, E. E. Knudsen, D. H. Lach, J. J. Lawler, D. F. Markle, B. M. Matsuda, A. G. Maule, J. H. Michael, A. T. Morzillo, D. L. Noakes, R. A. Pielke Jr., C. E. Peterson, D. Poon, J. H. Power, J. L. Rachlow, H. A. Regier, R. B. Rettig, H. J. Salwasser, J. R. Scarce, J. M. Scott, C. L. Smith, B. B. Stout, A. J. Talbot, N. S. Urquhart, R. L. Vadas Jr., and D. White. Some of these reviewers maintain different views than those expressed in this essay; thus, being acknowledged as a reviewer does not constitute an endorsement. The opinions and views expressed do not necessarily represent those of any organization.

Literature Cited

Armstrong, F. T. 2002. Ways to make analysis relevant but not prescriptive. Studies in Intelligence 46:37–43.

Béné, C. 2005. The good, the bad, and the ugly: discourse, policy controversies, and the role of science in the politics of shrimp farming development. Development Policy Review 23:585–614.

Boni, L., and K. L. Womack. 2003. Wall Street research: will new rules change its usefulness? Financial Analysts Journal 59:25–29.

Caldwell, P. 2005. Courting the expert: clash of culture? British Journal of Haematology 129:730–733.

Cohn, J. P. 2005. After the divorce: improving science at federal wildlife agencies. BioScience 55:10–14.

Doremus, H. 2005. Science plays defense: natural resource management in the Bush Administration. Ecology Law Quarterly 32:249–306.

Doremus, H., and A. D. Tarlock. 2005. Science, judgment, and controversy in natural resource regulation. Public Land and Resources Law Review 26:1–37.

Freyfogle, E. T., and J. L. Newton. 2002. Putting science in its place. Conservation Biology 16:863–873.

Hunter, M. L. 1996. Benchmarks for managing ecosystems: are human activities natural? Conservation Biology 10:695–697.

Karr, J. R. 2006. When government ignores science, scientists should speak up. BioScience 56:287–288.

Lach, D. L., P. C. List, B. S. Steel, and B. A. Schindler. 2003. Advocacy and credibility of ecological scientists in resource decision making: a regional study. BioScience 53:170–178.

Lackey, R. T. 2003. Appropriate use of ecosystem health and normative science in ecological policy. Pages 175–186 in D. J. Rapport, W. L. Lasley, D. E. Rolston, N. O. Nielsen, C. O. Qualset, and A. B. Damania, editors. Managing for healthy ecosystems. Lewis Publishers, Boca Raton, Florida.

Lackey, R. T. 2004. Normative science. Fisheries 29:38–39.

Lackey, R. T. 2006. Axioms of ecological policy. Fisheries 31:286–290.

Marris, E. 2006. Should conservation biologists push policies? Nature 442:13.

Matsuda, B. M. 1997. Conservation biology, values, and advocacy. Conservation Biology 11:1449–1450.

McCoy, N. H., and S. Atwood. 2005. Flaws in Orr's laws (and the paradigm that produced them): an abbreviated response. Conservation Biology 19:1318–1320.

Meine, C., M. Soule, and R. Noss. 2006. "A mission-driven discipline": the growth of conservation biology. Conservation Biology 20:631–651.

Mills, T. J. 2000. Position advocacy by scientists risks scientific credibility and may be unethical. Northwest Science 74:165–167.

Odenbaugh, J. 2003. Values, advocacy, and conservation biology. Environmental Values 12:55–69.

Pielke, R. A. Jr. 2004. When scientists politicize science: making sense of controversy over *The Skeptical Environmentalist*. Environmental Science and Policy 7:405–417.

Robinson, J. G. 2006. Conservation biology and real-world conservation. Conservation Biology 20:658–669.

Roebuck, P., and P. Phifer. 1999. The persistence of positivism in conservation biology. Conservation Biology 13:444–446.

Rykiel, E. J. 2001. Scientific objectivity, value systems, and policy making. BioScience 51:433–436.

Salwasser, H. 2004. Confronting the implications of wicked problems: changes needed in Sierra Nevada National Forest planning and problem solving. Pages 7–22 in Proceedings of the Sierra Nevada science symposium: science for management and conservation. General technical report PSW-GTR-193. U.S. Department of Agriculture Forest Service, Kings Beach, California.

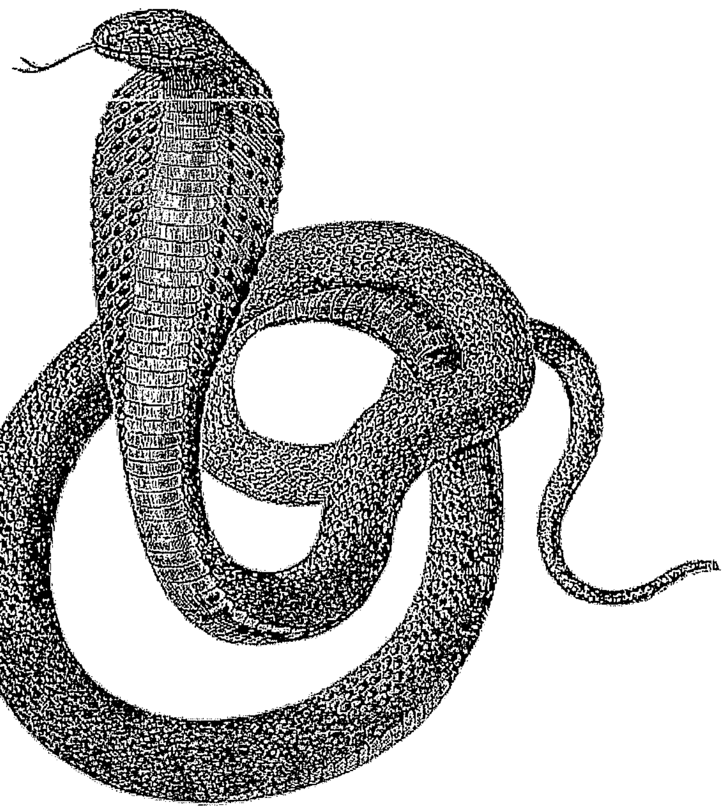
Sarewitz, D. 2004. How science makes environmental controversies worse. Environmental Science and Policy 7:385–403.

Scott, J. M., J. L. Rachlow, R. T. Lackey, A. B. Pidgorna, J. L. Aycrigg, G. R. Feldman, L. K. Svancara, D. A. Rupp, and D. I. Stanish. 2007. Policy advocacy in science: prevalence, perspectives, and implications for conservation biologists. Conservation Biology 21:29–35.

Sullivan, P. J., et al. 2006. Defining and implementing best available science for fisheries and environmental science, policy, and management. Fisheries 31:460–465.

Trudgill, S. T. 2001. Psychobiogeography: meanings of nature and motivations for a democratized conservation ethic. Journal of Biogeography 28:677–698.

van Houtan, K. S. 2006. Conservation as virtue: a scientific and social process for conservation ethics. Conservation Biology 20:1367–1372.



ATTACHMENT 15. From IRVINE ET AL. 2009

Table 16A (Continued). Annual North Pacific commercial catches salmon in millions of fish. 2008 estimates are preliminary.

	North America						North	Asia								
	Wash.,							Japan		Russia			Korea	Asia	Pacific
	Ore.,	Brit.		SE	Central	Western	Amer.	High		Rus.	For.				Total
Year	Cal.[1]	Colum.	Yukon	Alaska[2,3]	Alaska[3,4]	Alaska[2,5]	Total	seas[6]	Coast.[7]	Coast.[8]	Fleet	Coastal	Total	Total	
1968	5.17	35.89		30.44	24.73	7.14	103.36	56.04	15.01			16.43		87.47	190.84
1969	6.06	11.54		7.15	26.22	8.53	59.50	74.87	22.52			45.95	0.00	143.35	202.85
1970	6.59	25.75		14.85	29.60	24.00	100.80	53.08	16.29			17.59	0.00	86.96	187.75
1971	11.31	22.14		13.16	22.60	11.73	80.94	65.79	13.83			50.27	0.00	129.89	210.83
1972	5.81	28.30		18.05	9.45	4.46	66.07	54.42	9.09			16.05	0.00	79.56	145.63
1973	10.83	25.01		10.48	8.38	3.46	58.15	63.09	13.56			71.74	0.00	148.38	206.53
1974	8.54	21.73		8.88	7.59	5.40	52.15	54.91	13.72			28.03	0.00	96.66	148.81
1975	7.78	11.64		5.69	12.73	7.81	45.65	66.28	21.43			94.17	0.00	181.88	227.53
1976	8.50	22.04		8.02	25.92	10.48	74.97	51.10	13.24			44.49	0.00	108.83	183.80
1977	8.74	22.48		16.90	24.57	9.34	82.03	46.18	16.18			89.64	0.00	151.99	234.02
1978	6.48	25.65		25.02	36.47	20.81	114.42	29.43	18.31			49.88	0.00	97.63	212.05
1979	10.62	23.29		14.59	46.26	27.91	122.67	33.10	27.05			84.58	0.00	144.73	267.40
1980	5.73	19.65		18.71	55.02	36.29	135.39	32.39	24.24			64.22	0.00	120.84	256.24
1981	9.17	31.55		22.58	56.43	34.32	154.05	33.53	32.82			70.70	0.00	137.05	291.10
1982	8.05	20.10		29.33	57.77	24.48	139.73	31.24	28.22			41.16	0.00	100.62	240.36
1983	5.00	35.52		42.46	41.07	44.18	168.23	32.46	35.74			86.97	0.00	155.17	323.40
1984	4.48	19.01		32.04	62.71	38.90	157.13	27.40	37.00			48.97	0.00	113.37	270.50
1985	11.24	41.73		59.90	55.53	31.32	199.71	26.16	52.89			82.36	0.01	161.41	361.12
1986	9.07	39.82		54.63	50.97	23.32	177.81	15.53	46.26			40.59	0.01	102.39	280.20
1987	10.41	25.10		16.21	58.95	21.46	132.13	15.46	45.38			85.16	0.01	146.01	278.14
1988	7.89	37.20		17.49	59.81	23.26	145.64	11.59	48.49			41.56	0.01	101.66	247.30
1989	10.32	36.68		66.04	52.56	35.47	201.06	10.95	55.90			119.34	0.02	186.22	387.28

[1] Includes sport caught chinook and coho salmon.
[2] Catch in weight (1925-1959) estimated from catch in number and average weight by management area (60-69)
[3] Includes Southeast Alaska and Yakatat management areas.
[4] Includes Prince William Sound, Cook Inlet, Kodiak, Chignik, and South Alaska Peninsula management areas.
[5] Includes North Alaska Peninsula, Bristol Bay, and AYK management areas.
[6] Includes mothership, landbased gillnet and landbased longline fisheries
[7] Includes coastal and freshwater fisheries.
[8] Includes Northern Kurils, S. Sakhalin, and Japanese Concessional fisheries.

Table 16A (Continued). Annual North Pacific commercial catches salmon in millions of fish. 2008 estimates are preliminary.

	North America							Asia								
	Wash., Ore.,	Brit.		SE	Central	Western	North Amer.	Japan			Russia		Korea	Asia	Pacific
Year	Cal.[1]	Colum.	Yukon	Alaska[2,3]	Alaska[3,4]	Alaska[2,5]	Total	High seas[6]	Coast.[7]	Rus. Coast.[8]	For. Fleet[9]	Coastal	Total	Total	Total
1990	6.05	39.08		39.93	74.78	40.34	200.18	8.17	66.48			70.13	0.10	144.87	345.06
1991	8.79	40.81		70.86	86.32	32.35	239.12	6.85	67.70			165.02	0.10	239.67	478.79
1992	3.32	26.07		46.49	49.69	40.54	166.12	2.80	52.44			76.04	0.11	131.40	297.52
1993	6.95	34.92		72.27	73.78	47.00	234.91	3.46	72.59		9.83	95.24	0.12	181.22	416.13
1994	4.24	21.01		76.01	76.02	43.50	220.78	4.23	73.66		7.58	117.72	0.14	203.31	424.09
1995	5.47	20.68		64.55	101.79	51.51	244.00	3.82	80.70		11.71	118.17	0.14	214.54	458.55
1996	2.30	14.95	0.03	86.85	53.95	35.29	193.38	3.81	97.26		8.41	94.48	0.22	204.17	397.55
1997	4.71	20.67	0.01	45.53	61.77	15.84	148.53	2.42	78.25		10.15	145.97	0.22	237.00	385.53
1998	2.10	9.39	0.00	62.88	75.56	13.44	163.37	4.01	66.15		6.66	175.77	0.16	252.75	416.11
1999	1.19	8.07	0.01	97.77	90.31	28.73	226.07	4.05	54.83		6.74	169.17	0.11	234.90	460.98
2000	2.40	8.76	0.00	39.64	73.62	24.32	148.73	2.63	56.47		6.10	127.22	0.02	192.42	341.16
2001	4.30	11.36	0.00	81.40	76.82	16.95	190.83	2.57	64.66		4.53	143.03	0.04	214.83	405.67
2002	4.29	12.91	0.00	57.22	61.21	12.93	148.57	3.07	64.37		4.37	94.56	0.06	166.43	315.00
2003	5.11	17.26	0.01	68.07	91.95	17.93	200.32	2.99	80.15		2.19	147.11	0.04	232.47	432.79
2004	4.80	9.04	0.01	62.30	74.60	30.64	181.40	3.00	75.08		2.38	86.30	0.03	166.78	348.19
2005	3.45	11.90	0.00	70.60	120.90	30.20	237.04	2.67	72.83		2.47	181.75	0.02	259.74	496.78
2006	3.29	8.17	0.00	29.40	75.70	34.90	151.46	2.39	66.00		0.00	168.62	0.05	237.05	388.51
2007	3.09	8.81	0.00	58.60	116.50	36.70	223.70	2.32	73.98		0.00	213.23	0.09	289.62	513.31
2008	1.85	1.69	0.00	28.10	84.40	32.90	149.87		56.63		0.00	140.93	0.08	197.64	347.50

[1] Includes sport caught chinook and coho salmon.

[2] Catch in weight (1925-1959) estimated from catch in number and average weight by management area (60-69)

[3] Includes Southeast Alaska and Yakatat management areas.

[4] Includes Prince William Sound, Cook Inlet, Kodiak, Chignik, and South Alaska Peninsula management areas.

[5] Includes North Alaska Peninsula, Bristol Bay, and AYK management areas.

[6] Includes mothership, landbased gillnet and landbased longline fisheries

[7] Includes coastal and freshwater fisheries.

[8] Includes Northern Kurils, S. Sakhalin, and Japanese Concessional fisheries.

[9] Includes the Japanese driftnet fishery in the Russian EEZ.

ATTACHMENT 16.

Night-time predation by Steller sea lions

New insight into the feeding habits of these mammals will help conservation attempts.

Measures have been taken to curtail commercial fishing of walleye pollock (*Theragra chalcogramma*) in Alaska in an attempt to stop the decline of its endangered population of Steller sea lions (*Eumetopias jubatus*). But our night-time observations of these mammals in Prince William Sound using infrared scanning technology, combined with acoustic surveillance of their prey's behaviour, reveal that the sea lions feed exclusively on Pacific herring (*Clupea pallasi*), which are less abundant than pollock but are found closer to the surface at night.

Food limitation is the principal factor in the decline of Steller sea lion populations[1-4]. This decline could be explained by competition with commercial fisheries, as it has coincided with the growth of the pollock-fishing industry, which has become one of the largest fisheries in the world, or it could be related to a change in predator–prey relationships, possibly driven by ocean climate shifts[5]. Central to the uncertainty surrounding the drop in the numbers of Steller sea lions is a lack of observational data on their foraging ecology. There is no quantitative information available that directly relates the foraging behaviour of these animals to the abundance of prey species.

During the winter period, nutritional stress is high. Sonar surveys[6,7] of the abundance and distribution of adult Pacific herring and walleye pollock in winter have been made in Prince William Sound in Alaska since the early 1990s[8]. Steller sea lions were seen during the day near herring schools, but as no foraging activity was detectable, the significance of this co-occurrence was questionable.

We complemented our sonar surveys during March 2000 with infrared scanning of the Steller sea lions. This technology, which is widely used in night-time military operations and surveillance, enabled us to monitor the animals' activity during the hours of darkness. Our system had a $27° \times 18°$ field of view and a spectral response of 7–14 μm.

The estimated herring biomass in Prince William Sound in the sonar survey of March 2000 was 7,281 metric tonnes (95% confidence interval, 5,898–8,664). The estimate of pollock biomass was 28,277 metric tons (95% confidence interval, 26,034–30,420). Despite the much greater abundance of pollock, the infrared system revealed that foraging by Steller sea lions was exclusively on herring and was conducted only at night. Foraging activity was intense on dense herring schools (Fig. 1).

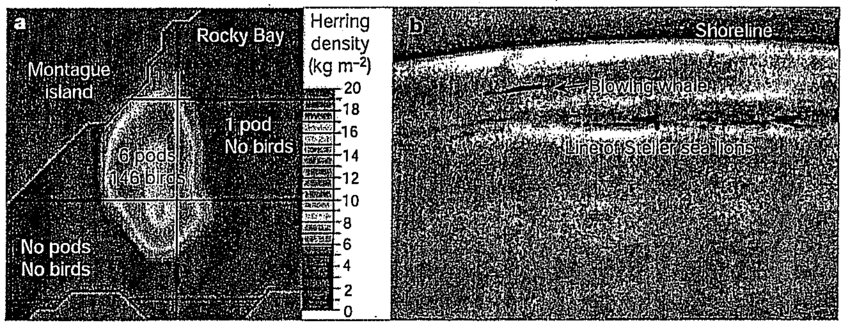


Figure 1 Location of groups (pods) of Steller sea lions around herring schools. **a**, Combined acoustic and infrared sensors reveal sea lions and birds located on the surface above the herring school at night in Rocky Bay, Prince William Sound (March 2000). **b**, Infrared video image showing a line of Steller sea lions and a humpback whale on the sea surface above a school of herring.

Steller sea lions were often observed swimming side by side in a row of 50 or more individuals along the edges of a school, suggesting that they were herding the herring. Humpback whales and seabirds were also seen to be feeding alongside the sea lions (Fig. 1). By contrast, no sea lions were coincident with pollock schools.

The sonar records revealed herring schools at depths of 10–35 m at night, but deeper during the day. Walleye pollock, on the other hand, remained at depths of over 100 m during both day and night. Pollock schools were also found in less protected regions and were further offshore. Although Steller sea lions are capable of dives exceeding 250 m (ref. 9), the more accessible distribution of herring at night may be the primary factor in the foraging behaviour of the sea lions. This distribution of herring is characteristic during an extended overwintering period in the North Gulf of Alaska.

Our results indicate that the dependence of Steller sea lions on herring as prey has been underestimated. The infrared scanning technology that has led us to this conclusion should also help in the evaluation of night-time foraging behaviour of other marine mammals and seabirds, with its remarkable ability to detect individual fish flipping on the sea surface at a distance of 5–30 m, as well as sea lions, whales and birds at over 100 m.

Gary L. Thomas, Richard E. Thorne
Prince William Sound Science Center, PO Box 705, Cordova, Alaska 99574, USA
e-mail: thorne@pwssc.gen.ak.us

1. National Research Council *The Bering Sea Ecosystem* (National Academic, Washington DC, 1996).
2. Castellini, M. Alaska Sea Grant College Program AK-SG-93-01, 4–13 (1993).
3. Merrick, R. L. *et al. Can. J. Fish Aquat. Sci.* 34, 1342–1348 (1997).
4. Loughlin, T. R. *Biosphere Conserv.* 1, 91–98 (1998).
5. Mantua, N. J. *et al. Bull. Am. Meterol. Soc.* 78, 1069–1079 (1997).
6. MacLennan, D. N. & Simmonds, E. J. *Fisheries Acoustics* (Chapman & Hall, London, 1992).
7. Thorne, R. E. *et al. FAO Fish. Rep.* 300, 217–222 (1983).
8. Thomas, G. L. *et al.* in *Developing and Sustaining World Fisheries Resources — the State of Science and Management* (eds Hancock, D. A. *et al.*) 606–613 (CSIRO, Collingwood, Australia, 1997).
9. Merrick, R. L. *et al. Polar Res.* 13, 105–114 (1994).

Genomics

Genes lost during evolution

One of the main conclusions presented by the International Human Genome Sequencing Consortium is that "hundreds of genes appear to have resulted from horizontal gene transfer from bacteria at some point in the vertebrate lineage"[1]. We noticed that a significant proportion of these human genes have closely related orthologues in the primitive eukaryote *Dictyostelium*. This observation supports independent gene loss in multiple lineages (worm, fly, yeast, plants) rather than horizontal gene transfer from bacteria.

The human genome sequence revealed 113 genes that share a high degree of identity with bacterial genes, but are absent in the completely sequenced genomes of *Caenorhabditis elegans*, *Drosophila melanogaster*, *Saccharomyces cerevisiae* and *Arabidopsis thaliana*[1]. Do these genes represent examples of horizontal gene transfer from bacteria to the vertebrate lineage, or were they present in both prokaryotes and early eukaryotes, but subsequently lost from all non-vertebrate eukaryotic lineages? Although this latter possibility may seem unlikely, we recently identified a gene in *Dictyostelium* that is clearly an orthologue of the gene that encodes soluble adenylyl cyclase in bacteria and vertebrates, but has not been identified in other eukaryotes[2]. *Dictyostelium* is located in the evolutionary tree between plants and the fungi/animal crown[3], and sequencing of its genome is approaching completion[4] (see also http://dictybase.org).

We used all 113 listed human genes to screen for homologous sequences in *Dictyostelium* (27 February 2001; see supplementary information). A TBLASTN screen of the *Dictyostelium* database yielded 36 sequences with expectation values of less than 10^{-10}. BLASTX analysis with the obtained *Dictyostelium* DNA sequences against GenBank identified 11 genes that represent clear *Dictyostelium* orthologues of human genes: the human sequences share a higher degree of identity with *Dictyostelium* than with bacterial sequences, and the bacterial sequences score more highly with respect to *Dictyostelium* than they do to humans (on the basis of BLAST expectation values). A further 17 *Dictyostelium* sequences share a high degree of identity with the human sequence, but are not obvious intermediates between the bacterial and vertebrate orthologues (see supplementary information). Thus, in at least 11 cases, the *Dictyostelium* and human genes have a common ancestor, eliminating the need to invoke horizontal gene transfer from bacteria.

One of the human proteins with an orthologue in *Dictyostelium* is monoamine oxidase (MAO). Phylogenetic analysis of this enzyme reveals a gene duplication late in the vertebrate lineage (MAO-A and MAO-B in Fig. 1). These paralogues seem to share a predecessor with *Dictyostelium*, indicating that monoamine oxidase was present in early eukaryotes, and implying that the gene has been lost in worm, fly, plants and yeast.

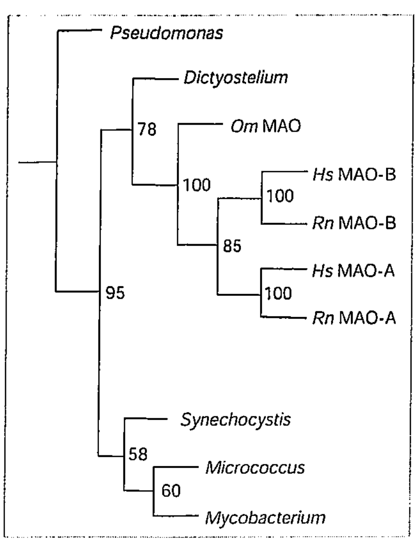


Figure 1 Phylogenetic analysis of monoamine oxidase (MAO). Numbers indicate values of bootstrap analysis ($n=100$). Hs, *Homo sapiens*; Rn, *Rattus norvegicus* (rat); Om, *Oncorhynchus mykiss* (rainbow trout).

Within the group of 113 genes proposed to have entered the human genome by horizontal gene transfer from bacteria, we have identified at least 11 that probably arose through normal evolution with gene loss in several lineages, suggesting that gene loss is not a rare event. With several ongoing genomic sequencing projects for lower eukaryotes, it will be interesting to see how many genes have truly undergone horizontal transfer.

Jeroen Roelofs, Peter J. M. Van Haastert
Department of Biochemistry, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands
e-mail: p.j.m.van.haastert@chem.rug.nl

1. International Human Genome Sequencing Consortium. *Nature* 409, 860–921 (2001).
2. Roelofs, J. *et al. Biochem. J.* 354, 697–706 (2001).
3. Baldauf, S. L. *et al. Science* 290, 972–977 (2000).
4. Kay, R. R. & Williams, J. G. *Trends Genet.* 15, 294–297 (1999).

Supplementary information is available at http://www.nature.com or as paper copy from the London editorial office of *Nature*.

Bone-marrow transplantation

Failure to correct murine muscular dystrophy

Bone-marrow cells have the potential to differentiate into other cell types such as muscle fibres, and can be transplanted into acutely[1] or chronically[2] damaged muscle as a way of delivering normal dystrophin (the protein that is defective or missing in Duchenne's muscular dystrophy) to the skeletal and heart muscle of *mdx* mice[2,3], an animal model for this disease. But the corrective potential of this approach has been hard to estimate against the high background of muscle fibres that spontaneously revert to synthesizing dystrophin, a feature of the original *mdx* mutation[4]. Here we test the long-term efficacy of bone-marrow transplantation in a different *mdx* mutant which is free of this problem and find that it has no impact on murine muscular dystrophy.

The *mdx4cv* mutant (in which a C-to-T nucleotide transition generates a stop codon in exon 53 of the dystrophin gene) has almost no background of revertant fibres in skeletal muscle[4]. We sublethally irradiated (900 cGy) a group of 15 8-week-old *mdx4cv* mice (C57Bl/6/Ly-5.2 background) and transplanted them with a total of 1.5×10^7 bone-marrow cells from a pool of 6-week-old, co-isogenic (C57Bl/6/Ly-5.1) animals. We killed the mice at regular intervals from 9 weeks to 10 months after transplantation, and monitored the engraftment of donor cells by cytofluorimetric analysis of the proportion of Ly-5.1 marker compared with Ly-5.2. The degree of chimaerism averaged $85 \pm 2.7\%$ in bone marrow (mean ± s.e.m.), $93 \pm 1.1\%$ in spleen, $92 \pm 2.9\%$ in thymus and $94 \pm 0.8\%$ in peripheral blood throughout the follow-up study.

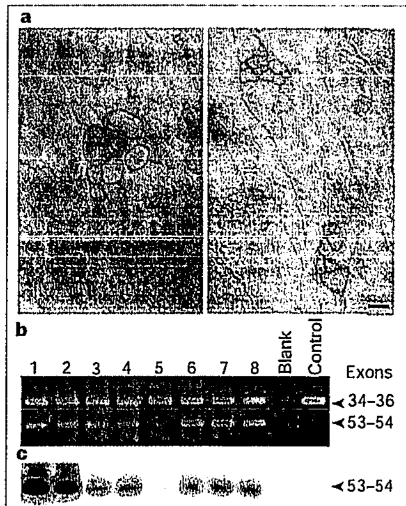


Figure 1 Expression of dystrophin in *mdx* mice 6 months after transplantation with bone-marrow cells from co-isogenic, normal donors. **a**, Immunohistochemical staining of frozen sections of tibialis muscle with an anti-dystrophin monoclonal antibody. Scale bar, 50 μm. **b**, Detection of wild-type dystrophin mRNA by RT-PCR amplification using specific primers for exons 53 and 54 in samples of total RNA extracted from skeletal muscle of transplanted *mdx* mice (lower bands). A fragment encompassing exons 33–36 in both wild-type and mutant dystrophin RNA is amplified as an internal control (upper bands). Lanes 1–8, samples from transplanted mice; 'blank', PCR assay without RNA; 'control', mock-transplanted *mdx* control. **c**, Southern-blot hybridization with an internal, specific oligonucleotide probe for exon 53.

We counted dystrophin-positive (dys^+) fibres in histological sections of representative muscles (tibialis anterior, quadriceps, diaphragm) after immunohistochemical staining with an anti-dystrophin antibody in transplanted and age-matched, mock-transplanted, control *mdx4cv* mice. Clusters of dys^+ fibres were apparent in muscle sections of transplanted animals, averaging $0.23 \pm 0.05\%$ (minimum, 0.06%; maximum, 0.54%) throughout the 10-month study (Fig. 1a). The proportion of dys^+ fibres in control animals averaged $0.14 \pm 0.03\%$ (minimum, 0.02%; maximum, 0.33%), a statistically significant difference ($F = 5.99$, $P = 0.02$). In neither group was there any significant increase in the number of dys^+ fibres in young (under 5 months) and old (over 12 months) animals. The average number of fibres contained in each dys^+ cluster varied from 3 to 30, with no significant change with age in either group.

To demonstrate the presence of normal dystrophin in the muscle of transplanted mice (the antibody does not distinguish between corrected and revertant fibres), we developed a polymerase chain reaction with reverse transcription (RT-PCR) assay to distinguish wild-type dystrophin messendifferential gametic imprinting, as well as on the amount of gene product needed for biological function.

Dolf Weijers*, Niko Geldner†,
Remko Offringa*, Gerd Jürgens†
*Institute of Molecular Plant Sciences, Leiden University, 2333 AL, Leiden, The Netherlands.
†Zentrum für Molekularbiologie der Pflanzen, Universität Tübingen, 72076 Tübingen, Germany
e-mail: gerd.juergens@zmbp.uni-tuebingen.de

1. Surani, M. A. *et al. Development* (suppl.) 89–98 (1990).
2. Lehmann, R. & Nüsslein-Volhard, C. *Dev. Biol.* 119, 402–417 (1987).
3. Vielle-Calzada, J.-P., Baskar, R. & Grossniklaus, U. *Nature* 404, 91–94 (2000).
4. Lu, P., Porat, R., Nadeau, J. A. & O'Neill, S. D. *Plant Cell* 8, 2155–2168 (1996).
5. Springer, P. S., Holding, D. R., Groover, A., Yordan, C. & Martienssen, R. A. *Development* 127, 1815–1822 (2000).
6. Mayer, U., Büttner, G. & Jürgens, G. *Development* 117, 149–162 (1993).
7. Waizenegger, I. *et al. Curr. Biol.* 10, 1371–1374 (2000).
8. Hamann, T., Mayer, U. & Jürgens, G. *Development* 126, 1387–1395 (1999).
9. http://www.plantsci.cam.ac.uk/Haseloff/GAL4/mGAL4.html
10. Thoma, S. *et al. Plant Physiol.* 105, 35–45 (1994).

Vielle-Calzada et al. *reply* — Our results, based on a study of 20 loci, indicate that the contributions by the maternal and paternal genome to early seed development in *Arabidopsis* are not equivalent, as evidenced by a lack of detectable paternal gene activity during the first few divisions after fertilization. As these loci are distributed throughout the genome, we inferred that early embryo and endosperm development are mainly under maternal control, but this may not be true for every locus and, as in X-chromosome inactivation[1], we would expect some loci to escape this silencing mechanism. We did not claim that maternal control is complete, but suggested that the activity of many genes during early embryo and endosperm formation could depend solely on transcription of the maternally inherited allele before and/or after fertilization.

Previously, early seed formation was thought to involve transcription from both parental copies immediately following fertilization, and maternal effects were considered rare or non-existent[2]. The time at which paternal activity can first be detected, however, is likely to vary from embryo to embryo and from gene to gene in different nuclei, as in *Drosophila*[3]. Weijers *et al.* report paternal expression of *AtRPS5A::GUS* as early as the two-cell stage, confirming that transcription in the zygote is not the rule for paternally inherited alleles, whereas transcription from maternal alleles has been demonstrated immediately after fertili-zation of the central cell[4]. We do not know what percentage of embryos show early *AtRPS5A::GUS* expression, nor the relative paternal and maternal activity, but there may also be less pronounced parent-of-origin differences.

New evidence supporting the non-equivalence of maternal and paternal genomes during early seed development is based on experiments with reporter genes[5–8] and genetic assays revealing maternal effects of genes thought to act purely zygotically[6] (S. Gilmore and C. Somerville, personal communication; J. Moore and U. G., unpublished results). Whether and at what stage expression of the paternal allele is sufficient for normal development will depend on the level of activity required for gene function. In a two-component transactivation system, no paternal activity was found during early seed development using *pOp::GUS* reporter lines with several activator lines[8]. Some early defects were evident with a *pOp::BARNASE* reporter, however, suggesting that paternal transcription is very low but is sufficient to cause *BARNASE*-induced defects in some embryos[8]. These results confirm the non-equivalence of maternal and paternal contributions to early seed development. Like imprinted genes in mammals, this difference is probably not absolute and may be due to different levels of maternal and paternal transcripts.

Our titration experiments indicated a difference in transcript levels of at least 80-fold for genes we tested by PCR. Weijers *et al.* report an expression difference in reciprocal crosses with *UAS:GUS* at the heart to torpedo stage (Fig. 1d), when we showed that both parental alleles are active at other loci we tested; indeed, this differential expression translates into an absence of detectable paternal activity at earlier stages using the *pOp::GUS* reporter system[8]. For some genes, such as *KEULE* or *KNOLLE*, low paternal expression may be sufficient for normal development, although very early defects (such as developmental delay) that are rescued by a paternal wild-type allele may be difficult to detect by scoring multinucleate embryos. Moreover, rescue of an early embryonic phenotype by a paternal wild-type allele provides no evidence against differences in parental transcript levels.

Although the exact time of paternal activation was not central to our report, most evidence so far suggests that no consistent paternal gene activity can be detected in the embryo or endosperm for several cell divisions. The results of Weijers *et al.* do not contradict our findings, but instead represent possible exceptions to a general rule. Specific genes that are important during early development (for example, those involved in cytokinesis that are distinctly regulated in the female gametophyte and the zygote[9]) may be under selection for earlier expression and be specifically activated early in development. Further investigation is required into how common early-expressing paternal genes are, and how maternal and paternal expression differs quantitatively.

Jean-Philippe Vielle-Calzada*,
Ramamurthy Baskar†, Ueli Grossniklaus†
*Cinvestav-Plant Biotechnology Unit, Irapuato, Mexico; †Institute of Plant Biology, University of Zürich, 8008 Zürich, Switzerland
e-mail: grossnik@botinst.unizh.ch

1. Goto, T. & Monk, M. *Microbiol. Mol. Biol. Rev.* 62, 362–368 (1998).
2. Howell, S. H. *Molecular Genetics of Plant Development* (Cambridge Univ. Press, Cambridge, 1999).
3. Pritchard, D. K. & Schubiger, G. *Genes Dev.* 10, 1131–1142 (1996).
4. Vielle-Calzada, J.-P. *et al. Genes Dev.* 13, 2971–2982 (1999).
5. Luo, M., Bilodeau, P., Dennis, E. S., Peacock, W. J. & Chaudhury, A. M. *Proc. Natl Acad. Sci. USA* 97, 10637–10642 (2000).
6. Springer, P. S., Holding, D. R., Groover, A., Yordan, C. & Martienssen, R. A. *Development* 127, 1815–1822 (2000).
7. Sorensen, M. B., Chaudhury, A. M., Robert, H., Bacharel, E. & Berger, F. *Curr. Biol.* 11, 277–281 (2001).
8. Baroux, B., Blanvillain, R. & Gallois, P. *FEBS Lett.* 509, 11–16 (2001).
9. Mayer, U., Herzog, U., Berger, F., Inzé, D. & Jürgens, G. *Eur. J. Cell Biol.* 78, 100–108 (1999).

corrections

Night-time predation by Steller sea lions
G. L. Thomas, R. E. Thorne
Nature **411**, 1013 (2001)

We stated that our acoustic surveys in Prince William Sound since 1993 and infrared surveys since 2000 suggested that these sea lions "feed exclusively" on herring. However, it has been drawn to our attention that this statement is misleading. In clarification, the sea lions were selectively targeting the relatively shallow (0–50-m depth) schools of Pacific herring (*Clupea pallasi*) at night as a source of winter forage to the exclusion of relatively larger and deeper (150–250 m) concentrations of walleye pollock.

Transatlantic robot-assisted telesurgery
J. Marescaux, J. Leroy, M. Gagner, F. Rubino, D. Mutter, M. Vix, S. E. Butner, M. K. Smith
Nature **413**, 379–380 (2001)

The correct address of the third author of this communication is Division of Laparoscopic Surgery at Mount Sinai School of Medicine and Mount Sinai Medical Centre, New York 10029, USA.

Peptide antibiotics in mast cells of fish
Umaporn Silphaduang, Edward J. Noga
Nature **414**, 268–269 (2001)

The concentrations listed in Table 1 are in μg ml^{-1}.

erratum

Nitrate flux in the Mississippi River
G. F. McIsaac, M. B. David, G. Z. Gertner, D. A. Goolsby
Nature **414**, 166–167 (2001).

In Fig. 1 of this communication, the line referred to as "black" is in fact blue; also, in the fourth line of the third column, *P* should be greater than 0.05.

ATTACHMENT 17.

Auke Bay Laboratories (ABL)

Habitat and Marine Chemistry Program

Humpback Whales in Seymour Canal, Southeast Alaska: Numbers and Forage Base

Figure 2. A humpback whale "flick feeding" in Seymour Canal. With the breakdown of the thermocline in November, euphausiids were present at the surface simplifying prey identification. Photo by John Moran.

As part of continuing research on the effect of predation on Pacific herring, an estimated 240 humpack whales were observed in November (Fig. 2), with 210 photographically identified between Juneau and Seymour Canal. These observations are an extension of work in Sitka, Lynn Canal, and Prince William Sound to determine the forage base of humpback whales in fall and winter and whether they are impacting herring stocks, possibly to detrimental levels.

John Moran (ABL) in collaboration with Jan Straley of the University of Alaska Southeast completed a 10-day research cruise to Seymour Canal during mid-November 2009. The large concentration of humpback whales at this time of year is consistent with earlier work by Straley where well over 100 whales have been present in a 40-km stretch of Seymour Canal in November for a number of years.

These late-season humpbacks are not new to Seymour; Straley has been keeping track of them since 1979. Why are they there? Seymour Canal has high concentrations of euphausiids. Researchers with ABL's Habitat and Marine Chemistry Program are trying to understand why the area is so productive by looking at parameters such as oceanographic features, euphausiid energetics, and predator abundance.

Research from Seymour Canal will complement humpback whale foraging data collected in Prince William Sound, Lynn Canal, and Sitka Sound. In Prince William Sound and Lynn Canal, herring have been identified as the primary prey for humpbacks. Sitka Sound has both euphausiids and abundant herring stocks. Euphausiid-filled Seymour Canal provides some contrast on how these late season whales are using different foraging strategies to fuel up before migrating to lower latitude breeding areas.

Direct observations of whale predation are often difficult to assess, and prey type is often inferred from acoustic signal. However, recent analysis of fatty acid and stable isotope analysis from whale blubber and prey samples confirm our field observations—whales in Prince William Sound are feeding at a higher trophic level on herring.

The impact of whale predation on the struggling herring stocks of Prince William Sound and Lynn Canal is not trivial. For example, whales in Prince William Sound have the capacity to consume between 18% and 32% of the current spawning stock biomass between September and March; basically they have replaced a former commercial fishery.

No commercial fishery for herring has been permitted in Lynn Canal since the 1970s, and only two fisheries have been permitted in Prince William Sound in the last 17 years.

By John Moran

<<< previous next >>>